FAO PANEL OF EXPERTS ON PESTICIDE SPECIFICATIONS, REGISTRATION REQUIREMENTS AND APPLICATION STANDARDS

GROUP ON PESTICIDE APPLICATION STANDARDS

Report of the Sixth Meeting
Rome, 16-20 December 1985

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Meeting Report
AGP: 1985/M/1

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Food and Agriculture Organization of the United Nations
Rome, 1986

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1. INTRODUCTION

The Sixth Meeting of the Panel of Experts on Pesticide Specifications Registration Requirements and Application Standards was held in Rome from 16-20 December 1985. This meeting, the first meeting of the Group on Application Standards, was opened by Dr. L. Brader, Director of the Plant Production and Protection Division, who pointed out the great importance of the subject and the recognition it had received in the International Code of Conduct on the Distribution and Use of Pesticides. The Code had been recently unanimously adopted by Member Governments. In welcoming the members, he stressed that FAO depended on the Panel for advice in preparing guidelines and in improving training, so that the application of pesticides could become more efficient and safer.

Dr. G.A. Matthews was elected Chairman of the Meeting, Professor L. Roth and Dr. Combellack were appointed joint Rapporteurs and Dr. A.V. Adam served as Technical Secretary.

1.1 Terms of Reference

The Group had been convened by the Director-General to:

a) recommend application techniques for the control of major pests of principal food and fibre and other crops;

b) develop standard procedures for evaluation of equipment, in collaboration with other international agencies;

c) adopt uniform methods of assessing pesticide deposition;

d) promote training to improve application of pesticides, with particular emphasis on safety, efficacy and maintenance of equipment, through practical field courses in developing countries;

e) promote research to improve efficiency of application of pesticides;

f) consider any other matters pertaining to safe application of pesticides.

These terms of reference for the Group were defined by the Ad Hoc Government Consultation on Pesticides in Agriculture and Public Health, Rome 7-11 April 1975.

1.2 Review of Current Status of Pesticide Application Technology

The Group noted that most pesticides are formulated for mixing with water and are applied as spray through a wide range of ground or aerial equipment, normally fitted with a type of hydraulic nozzle. Although effective, the technique is not very efficient as only a small proportion of the emitted spray actually

reaches its intended target. Although the technqiue is widely used with tractor mounted or trailed equipment in developed countries, but relatively few small- holder farmers in the developing countries use pesticides. The principal item of equipment, the non-motorised knapsack sprayer is not always acceptable where there is a lack of water near fields, lack of capital or credit to purchase equipment, and only poor quality sprayers are available with inadequate or non-availability of spares. The work load to operate the equipment is also unacceptable to many farmers. Furthermore, considerable contamination of the operator occurs while walking into the spray. Poor application by those who do use non-motorised equipment, is caused by inaccurate calculation of dosage rates, poor pressure control and failure to calibrate equipment.

In consequence, overdosing (resulting in higher residues and phytotoxicity) or underdosing (poorer pest control) occurs in many countries. A wide range of nozzle types are available, but most farmers only use nozzles supplied with the machine and seldom change them despite considerable wear. Considerable improvement in application could be achieved with commonly used hydraulic nozzles with relatively small changes in technique, including choice of nozzles and their replacement in relation to erosion of the orifice, the provision of more durable equipment, improved pressure regulation and improved training.

The Group recognized the value of ultra-low volume (ULV) application of pesticides with improved conservation of diluent, especially where water supplies are poor especially in the semi-arid areas. However, a lack of suitable less volatile formulations, spare parts and batteries for certain equipment has restricted its acceptance and consideration must be given to any increased hazard due to using a more concentrated spray. Alternative power sources under development, including pneumatic drive, solar energy, and rechargeable battery systems were needed to extend the usefulness of the system.

Recognizing that electrostatically charged sprays are not widely used at present the method has the advantage that pesticide deposition on crop canopies can be improved. The Group felt that more attention should be given to its development especially as some hand-held equipment is already available. An important advantage of charged sprays is that localized deposition can reduce direct contamination of the soil and neighbouring crops, and thus minimize interference with the activity of certain beneficial insects.

The Group recognized the special problems of projecting spray into tree canopies and that further consideration needs to be given to equipment design to optimize air flow on air carrier sprayers.

The Group accepted that aerial application provided the most rapid treatment of large areas, especially over difficult terrain,

but environmental criticism will necessitate further improvements in operation factors to reduce drift beyond treated areas.

1.3 Integrated Control

The Group recognized the importance of pesticide use as a fundamental component of Integrated Pest Management (IPM) and confirmed that proper equipment has a critical role in achieving better timing and duration of application and more selective placement of pesticide deposits. It was agreed that biological agents and pheromones may present specific formulation and application problems requiring specialized application methodology. In some cases pheromones and baits may be used in conjunction with other pesticides.

1.4 Control of Birds as Pests

Avian species present very difficult targets and both avicides and application technique were inadequate. It was agreed that development of avicides with rapid knockdown and degradation and novel application methods, e.g. using anchored balloons to elevate spray equipment to disperse pesticides in fine droplets without noise to high roosting sites or adhesive materials were necessary.

1.5 Operator Safety

The Group was not aware of any existing extension material which could adequately communicate the importance of safety needs of all users of pesticides and others, with the exception of the WHO Multi-Level Course on the Safe use of Pesticides. Furthermore it was agreed that audio-visual materials are needed which use pictures of people familiar to local audiences to portrary safety practices, and the use of national garments, such as turbans, sombreros, galabias and ponchos, for body protection. In addition to improved training manuals and extension aids the Group felt that there was a need for practical training on safety at the farmer level. The development and assessment of improved inexpensive, comfortable and effective protective clothing, particularly in hot climates, must be encouraged.

The Group agreed that safety in the use of equipment must take account of other health hazards, especially those associated with excessive sound, vibration, weight and heat. It was also recognized that more appropriate packaging such as size, ease of opening, dispensing and subsequent disposal, was necessary for small-scale use to enable safer handling and to prevent the reuse of packages.

The Group noted the references to safety in the International Code of Conduct on the Distribution and Use of Pesticides and agreed that these should form the basis for programme activities of the Panel.

1.6 Environmental Aspects

The need for an overall environmental strategy to protect the flora and fauna in sensitive and high risk areas was recognized by the group as a priority. It therefore stressed the need for the Guidelines developed by FAO "Guidelines on Enviornmental Criteria for the Registration of Pesticides, 1985" also should be brought to the attention of relevant research and extension personnel so that these are implemented.

The Group recognized that faulty application is a major contributor to off-target contamination. It was acknowledged that pesticide drift poses a significant environmental problem if application is carried out under adverse meteorological conditions or if an incorrect application technique is selected. The Group thus emphasized the need to train spray applicators in the correct selection and use of application equipment.

The Group also recognized that the use of aircraft present a greater risk for off-target contamination than ground equipment. The training of pilots in the safe application of pesticides was identified by the Group as being inadequate in most countries. The Group therefore stressed the urgent need for an appropriate pilot training scheme which FAO should support and encourage.

2. SPECIFICATIONS FOR PESTICIDE APPLICATION EQUIPMENT

The Group recognized that there are serious deficiencies in the performance of equipment used to apply pesticides, especially in developing countries, and this results in ineffective pest control, health hazards, environmental contamination and excessive costs. An effective way of reducing the problem of poor equipment is to establish international specifications of performance and testing procedures for the most commonly used equipment, such as those successfully used by WHO for disease vector control. Such specifications which would ensure acceptable design, performance, durability and reliability could be developed for agricultural use, in cooperation with appropriate institutions designated as Collaborative Centres and with equipment manufacturers.

The format of specifications and data sheets, examples of which are shown in Annexes 2, 3 and 4 was agreed by the Group for use by FAO in preparing international specifications for pesticide application equipment.

Specific equipment for which appropriate specifications should be given priority are listed in the recommendations (No. 3, on page 8).

3. TRAINING IN PESTICIDE APPLICATION METHODOLOGY

The Group recognized that frequently the technology of safe and effective application of pesticides was not reaching the farmer, as evidenced by the incidence of poisoning and the

problems arising from incorrect use. In view of these serious shortcomings, the Group recognized the critical importance of practical training courses which need to ensure that those trained have the ability and means to transfer the information to the farmer. FAO has already conducted several courses in which part of the time was devoted to the training of farmers by the trainees, with very satisfactory results. Based on this experience, a draft manual entitled "Manual on the Proper Selection and Use of Ground and Aerial Equipment for the Application of Pesticides" has been prepared and this was reviewed. The Group welcomed the contents and the way it was presented in modular form so that individual sections could be used independently for specific training needs. It was agreed that this manual was highly suitable for use in training activities and after technical editing it should be published as soon as possible.

The use of the manual would be augmented by additional training aids, such as kits of equiment, including sprayers, basic tools, spares and also cut-away models of sprayers, slide sets, posters and brochures. Recent developments of audio-visual technology especially video tapes were considered to be an important additional means of providing improved transfer of information on practical techniques, but this needs to be prepared in collaboration with extension staff trained in the country where training is offered to ensure use of appropriate communication skills and local cultural background.

A document listing the availability of short-course training activities which include pesticide application technology has been published by FAO. The Group noted that this was a useful contribution and its continuation and upadating should be encouraged and given wide publicity. Certain specialized courses, known to the Group are listed in Annex 1 under their respective Institutes.

4. RESEARCH ON PESTICIDE APPLICATION TECHNOLOGY

The Group recognized that very little research on application technology is in progress, except in a few specialized laboratories mainly in developed countries. The Group noted the striking imbalance between the funding expended on research and development of new chemicals and that on new or improved application technology. This imbalance has contributed to many of the problems associated with pesticide use and this factor has been fully recognized. The Group felt strongly that proportionally more effort should be directed towards applied research, particularly to the practical needs of small-scale farmers. Further, a need was identified to train research-orientated scientists to create multidisciplinary teams in developing countries. The Group believed that emphasis should be placed on developing systems for pesticide application involving both formulation and equipment, appropriate for small-scale farmers. Such research needs a strong link between extension and research staff to ensure the transfer of technology to the farmer.

Clearly the pesticide industry, in cooperation with equipment manufacturers, should play a leading role in ensuring the availability of appropriate equipment which can significantly improve the effective, safe and economic application of their products.

One way in achieving this aim is to encourage International Agricultural Research Institutes to set up cooperating centres specializing in pesticide application technology. The work of such centres should consider operator safety as well as application problems for small-scale farmers.

International Code of Conduct on the Distribution and Use of Pesticides

The Group studied the Code and commended the comprehensive manner in which it has covered the factors involved in the use of pesticides. However, it felt that certain aspects related to pesticide application justified amplification, and recommendations were made (page 7) for future consideration when the Code is reviewed.

Guidelines for Safe and Efficient Use of Pesticide Application Equipment

The Group took note of the International Code of Conduct on the Distribution and Use of Pesticides and the recommendation of the 4th Session of the FAO Panel of Experts on Agricultural Mechanization and agreed that guidelines were needed to ensure safe and efficient use of pesticide application equipment. The Group noted that guidelines (see Annex 6) are used in certain countries and agreed that FAO should promote the use of similar guidelines for the different types of application equipment. Further, that information on application technology should be incorporated, where appropriate, into Manuals covering specific crops. It was felt that rather than update earlier FAO publications on aerial and ground equipment for pesticide application, (Ref. FAO Development Paper No. 94 (1974) and FAO Ag. services bulletin no. 38 (1979a)) the Group felt that highest priority should be given to publishing the modular training manual (see pages 4 and 5).

RECOMMENDATIONS

The Group reviewed all aspects of the safe and efficient application of pesticides as outlined above and made the following recommendations:

1. In relation to the International Code of Conduct on the Distribution and Use of Pesticides, the Group recommended the following comments should be considered:

a) That one of the Objectives should read **1.5.5 promote the safe, effective and efficient use of pesticide application systems.**

b) That in the Section on Definitions, pesticide application should be included as follows:

Pesticide Application - The process by which a pesticide is transferred from its container involving dilution and mixing, where necessary, its subsequent distribution over a target area, its dispersion in space or its strategic placement within or on the target, by usng appropriate equipment.

c) That governments, industries and other organizations should provide information on specific application techniques in as well as information on pesticides. This should include choice of nozzle, calibration techniques, and method of using equipment. This will require preparation and publishing of appropriate "guidelines".

d) As effective use of pesticides requires correct use of application equipment, governments and industries are urged to provide more resources for training in application techniques which should form part of an integrated pest management programme, especially as residue problems are mostly associated with inadequate or inappropriate applicator training, leading to incorrect choice of pesticide, and application practices.

e) That in hot climates, full protective clothing is impractical and it is too expensive for small-scale farmers, so the Code urging governments to "avoid" using the most toxic pesticides should be strengthened, and that further attention needs to be given to the improvement of protective clothing.

f) That application techniques, modification of formulations and equipment appropriate to the small-scale farmer should be developed.

g) That the risk of improper packaging, and hazards associated with manufacture in a developing country could be reduced, if approved repackaging facilities to suit local farm requirements are encouraged.

h) That further critical information on method of application should be provided on the label.

i) That symbols and pictograms should be field tested to ensure appropriate interpretation.

j) That specifications and performance requirements should be established to ensure acceptable quality of pesticide application equipment.

2. To revise and publish the draft modular training manual, "The Manual on the Proper Selection and Use of Ground and Aerial Equipment for the Application of Pesticides", corporating new methods on spray coverage, granule and dust application, seed treatment, weed wipers and tree injection. Priority should be given to the publication of selected modules covering lever-operated knapsack sprayers, compression sprayers, motorized knapsack mistblowers, rotary nozzle sprayers and electrostatic sprayers. These bound modules should b issued in a loose-leaf holder.

The section on Criteria of the Selection of Equipment should cover capital costs, durability, area to be treated, speed of treatment, labour requirements, maintenance and other factors. All equipment sections should cover the design, use, calibration and maintenance of equipment. Each module should include a list of equipment required for practical training and further reading including extension material. An initial section is needed to describe the purpose and use of the Manual.

3. FAO should establish performance specifications for the commonly used pesticide application equipment especially for small-scale farmers, and recognizing the positive results already achieved by WHO for equipment used in public health, should adopt a smiliar procedure for agricultural equipment. The testing procedures should be carried out by Institutes designated by FAO as Collaborating Centres. Priority should be given to the lever-operated knapsack sprayer, rotary nozzle sprayers and hand- held electrostatic sprayers.

4. FAO should expand its activities in practical training courses on application technology, especially at the extension/ farmer interface. To assist this, closer liaison is needed between technical staff and communication specialists to improve transfer of information and skills to individual farmers on the application of pesticides. FAO should also develop additional appropriate visual aids including audiovisual tapes to illustrate application technology for training courses, and should support the use of audiovisual equipment to prepare audiovisual tapes during training courses, to allow participants to evaluate their progress.

5. Encouragement should be given to the development of research units, attached to existing centres, that would specialize in practical application technology to adapt existing systems and new technology to enable its introduction into small-scale farmer systems, in particular to assist in the integration of pesticide use with other pest control practices. Such research on development in ULV spray techniques, including improved nozzle design, and power supply, should be encouraged.

6. The Group agreed on the adoption of the WHO spray classification (see Annex 7) with the amendment that coarse sprays should have a volume medium diameter (VMD) larger than 300 um. The Group also agreed to adopt a standard nozzle code to assist in making recommendations on specific application methods, in relation to the spray classification, and the EPPO classification of spray volumes (see Annex 9).

7. The Group urged that FAO should encourage the training of agricultural pilots in the safe application of pesticides.

8. The Group also recommended that a) the use of improved quality nozzles should be encouraged to reduce the effect of orifice wear by abrasive particles suspended in water. b) Separate spaying equipment should be used for herbicides in mixed farming areas with crops susceptible to phytotoxicity as chemical residues are extremely difficult to remove from equipment, especially from plastic hoses. c) When sampling sprays, the true target, i.e. lower leaves, stems, etc. are used or alternatively thin cords, rather than flat plates which are unrepresentative of biological targets, except for soil applied chemicals.

Future Work of the Group

The Group identified the following areas which should receive its attention in the future.

1. Development of appropriate guidelines on pesticide application to help strengthen the International Code of Conduct on the Distribution and Use of Pesticide. Priority for these guidelines, published by FAO, should be for specific crops such as cotton, rice and vegetables on which most pesticides are used.

2. Development of a vocabulary of pesticide application technology in conjunction with other interested international agencies.

3. Encouragement of the development of more precise application recommendations in relation to droplet spectra requirements and appropriate nozzle codes.

4. Consideration of harmonization of colour codes for spray nozzles.

5. Monitoring the progress in training courses and research programmes and identification of problems and advising on future improvements.

6. Consideration of other major application problems, such as tree-crop spraying, fungicide application, aerial spraying, and granule and dust application. Also metering of sprays and other control devices should be considered, as well as the development of simple means of assessing spray distribution.

Work by other Major International Organizations

Other International Agencies concerned with Pesticide Application include:

the **International Standards Organization (ISO)**

Their Committee SC6 - "Equipment for Crop Protection" is principally concerned with the specification of test procedures for tractor mounted equipment. It has also produced a Vocabulary (ISO 5681 - 1981) which needs to be amended by this Group for FAO.

The European and Mediterranean Plant Protection Organization (EPPO)

EPPO organized a Conference on pesticide application (Ref. EPPO Bull. 13 published 1983) held in Budapest.

ANNEX 1

Sixth Session of the FAO Panel of Experts on Pesticide Specifications, Registration Requirements and Application Standards

Group on Application Standards
Rome, 16-20 December, 1985

AGENDA

1. Review of Current Status of Application Practices

   1.1 An overview of present pesticide application practices and scope for improvement and development of new technology

   1.2 Nozzle design limitations in relation to spray volume, droplet size range and other factors

   1.3 Integrated Control

   1.4 Control of Migrant Pests

   1.5 Operator Safety

   1.6 Environmental Aspects

2. Specifications for Pesticide Application Equipment

   2.1 Methods of testing and evaluation of pesticide application equipment

   2.2 Proposals for preparing specifications

3. Training in pesticide application methodology

   3.1 Manual

   3.2 Other training aids

4. Research on pesticide application technology

5. The International Code of Conduct on the Distribution and Use of Pesticides

6. Guidelines on safe and efficient use of pesticide application equipment

7. Future work for panel

ANNEX 2

Example of specification for hand-operated compression sprayers as published by the World Health Organisation to show the format and testing procedures.

1. SPECIFICATIONS [1]

1.1 Description

The sprayer shall be of cylindrical type and equipped with a hand-operated air pump for pressurization, hose, cut-off valve, lance, nozzle and other accessories as specified by the user agency. The sprayer with fittings assembled shall have no sharp edges or projections that might injure workmen during normal operation.

1.2 Materials of construction

The tank including filler cover shall be made of corrosion-proof stainless steel or alternative materials, including plastics provided that the finished unit complies with all other requirements of this specification. All joints shall be welded and the resultant welds shall have a tensile strength equal to that of the parent material.

No wooden parts shall be used in the construction of any part of the sprayer. No solder containing lead and/or tin as major components shall be used in the construction of sprayers or component parts thereof except on joints between the lance cut-off valve, nozzle body and dip-tube provided that all tests pertaining to these items are satisfactory. Solder may be used in construction of strainers where these items are readily and easily replaceable. All threaded connections and all joints shall be leakproof at twice the maximum working pressure without the use of cements, shellacs, chemical solvents or binders of any kind.

The sprayer shall be clearly and permanently marked to indicate the full charge in litres, this shall not be more than three-quarters total capacity of the tank. The maximum working pressure shall be clearly and permanently marked on the tank. Other markings shall include year of manufacture, specification number and may also include the manfacturer's name.

All parts of the sprayer shall be resistant to rust or corrosion by the formulations specified by the purchasing agency.

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[1] **IMPORTANT.** While this specification is designed to provide the best equipment for field workers, proper operation and maintenance of the sprayer are absolutely necessary if effective and continuous operation in the field is to be ensured.

1.3 Capacity

The capacity of the tank shall be between 7.5 and 15 litres total liquid and air capacity with all accessories in place ready for operation. The exact capacity shall be specified by the purchasing agency.

1.4 Dimensions

The diameter of the tank shall not exceed 25 cm or be less than 15 cm. The maximum height of the tank from the bottom of the base to the uppermost point of the top shall not exceed 60 cm and the height from the base of the sprayer to the handle in its lowest position shall not be over 70 cm.

1.5 Weight

The weight of the sprayer, when empty but equipped for operation, shall not exceed 6.5 kg.

1.6 Tank

1.6.1 Leakage

Every tank with all its fittings attached shall withstand an internal hydrostatic pressure of twice the maximum recommended working pressure or not less than 1000 kPa when subjected to the test described in section 2.1.

1.6.2 Fatigue

A sample of tanks with all fittings shall withstand without failure 12 000 pressure cycles at 0-500 kPa or the maximum working pressure when subjected to the test described in section 2.2.

1.6.3 Strength on impact (dropping)

The tank shall withstand being dropped six times in each of the four positions described in section 2.3. The tank shall be checked for leakage after the drop test by repeating the test described in sections 1.6.1. and 2.1.

1.7 Tank fittings

1.7.1 Fastening for lance

The sprayer shall be provided with means for fastening the lance securely and protecting the nozzle when not in use. The fastenings on the sprayer shall withstand the drop test described in section 2.3, to the extent that they may be bent back to their original shape and remain functional.

1.7.2 Straps

One or two straps, as desired by the user agency, made of uniformly woven web-cotton belting, free from effects and joins,

having straight and firmly woven selvedges, or synthetic material, shall be provided. Each strap shall be not less than 5 cm wide and 3 mm thick, and the length shall be readily adjustable from about 50 cm to 100 cm. The edges shall not fray at all. At the option of the purchasing agency, the straps shall be proofed against mildew. The strap shall not be acceptable if it fails when tested in accordance with the method described in section 2.4. In addition the tensile strength shall be not less than 360 kg.

The straps shall be easily attachable to the tank by means of corrosion proof fastenings that shall have a strength equal to that of the fastening provided on the sprayer. The fastenings should be made and attached in a manner that will prevent the strap from being trapped under the tank bottom when filling or pressurizing.

The straps, fastenings and clips shall not show structural failure when subjected to the tests described in sections 2.3 and 2.4. If the strap fastenings provided are of the spring clip type, the clips should be designed in such a manner that a safety lock or wire may be applied to prevent accidental detachment from the sprayer. These spring type clips shall be provided with drilled holes to receive a suitable wire fastener in case the spring is weakened excessively.

Any D buckle or adjustment device for adjustment of the length of the strap should maintain its set position and not move when subjected to the test described in section 2.4, nor should it move when the sprayer filled to maximum liquid capacity is suspended from the test bar for one hour by the straps.

1.7.3 Foot rest

The bottom part of the spray tank shall be equipped with a flanged area or foot rest designed to steady the apparatus while it is pumped. A foot rest shall be hinged to fold up against the tank side and remain there until required. The bearing area available to the foot shall be not less than 35 cm^2. The device shall remain operational after the drop test described in section 2.3.

1.7.4 Pressure gauge

A back-mounting pressure gauge, preferably the diaphragm type, with a scale reading from 0 to 70 kPa shall be fitted. The body material shall be brass, bronze, or other metal or material having equal or superior corrosion resistance and strength. The sensing element chamber must be "non-pocketing" to prevent interference with the proper operation of the sensing element by the deposition and accumulation of spray materials. In the case of diaphragm type, the inlet port shall have an easily removable filter assembly, or other means to prevent the entry of suspended material. The dial cover shall be shatterproof and moisture-proof

and permit easy reading of the tank pressure. A sample gauge should meet the specified requirements when subjected to tests described in section 2.14. A plug shall be provided for the opening into which the pressure gauge fits to provide an airtight and liquid-tight closure, should the gauge not be required.

Alternatively a colour coded indicator that is part of a pressure relief system may be fitted provided that the maximum working pressure is clearly defined.

1.7.5 Filler opening

The filler opening shall be not less than 95 mm in diameter if circular, or 90 mm in minor axis if oval. It shall have no sharp edges. The filler opening cover shall preferably be attached to the tank with a chain or equivalent capable of withstanding a breaking strain of not less than 50 kg.

1.7.6 Removable fittings

No set screws shall be used for fastenings.

1.7.7 Riveted fittings

No rivets shall penetrate the pressurized portion of the tank.

1.7.8 Pressure-release devices

The tank shall be equipped with a valve or other device designed to release pressure from the tank without danger to the operator and without requiring that the tank be inverted. It shall be simple and easily operated. Threaded fittings to the pressurized part of the tank having a diameter of 1.3 cm or more shall be channelled to provide release of pressure during removal.

1.8 Pump

1.8.1 Construction

The pump cylinder shall be of seamless or electrically welded construction, if made of stainless steel or other metal. The pump cylinder shall be a separate part, easily detachable from the tank, tank top, or any other component of the sprayer. The cylinder shall withstand internal and external application of pressures up to twice the highest specified operating pressure but not less than 1000 kPa without structural failure. If the pump has a cupwasher the upper part of the cylinder should be cone shaped to facilitate servicing.

1.8.2 Capacity

The pump shall be so designed and constructed to produce, when new, the maximum working pressure, on completing not more than 70 full pump strokes under the following conditions:
(1) the tank shall be filled with liquid to the maximum liquid charge mark specified in section 1.2;

(2) preliminary strokes may be applied to ensure that the pump is functioning correctly provided that the tank is depressurized prior to the test.

1.8.3 Check valve

The pump check valve shall be so designed as to prevent any leaking of liquid into the pump cylinder over a period of 15 minutes when the tank is pressurized to maximum recommended working pressure and the check valve is fully submerged. This test shall be made after the sprayer has undergone simulated use filled and discharged 20 times with an inert powder suspension at 20 g/ litre. All parts of the check valve shall be easily serviceable without use of special tools.

1.8.4 Plunger shaft [1]

The plunger shaft may be of steel or alternative material and be either a solid rod, tube or an extrusion. A resilient stop shall be provided to limit upward travel of the plunger shaft to a point at least 3 cm from the top of its stroke. A resilient stop shall be provided also as a stop at the bottom of the stroke. Construction stability shall be such that at the top of the stroke, the plunger shaft shall have a displacement of not more than 15 mm on either side of its vertical axis under a horizontally applied load of 0.5 kg. At the top of the stroke the pump handle shall not be more than 105 cm above the base of the sprayer. This test shall be done after 10 full pressurizations of the tank to 385 kPa.

1.8.5 Plunger cup

The plunger cup, if made of leather, shall be shaped from chrome leather and, unless otherwise specified, shall be treated with suitable fungicide as specified by the purchaser. It shall be not less than 1.5 mm thick and the cup leather skirt shall be not less than 13 mm in length. A cup spreader shall be provided to press the cup skirt against the pump cylinder wall. Cups of synthetic rubber, oak-tanned leather, or plastic, or O-rings of equal strength and resistance to solvents may be supplied at the option of the user agency.

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[1] The term "plunger" has been commonly used for the piston of these pumps.

1.8.6 Pump handle

A T type handle shall be provided that will allow the operator to grip it comfortably with both hands. In general its length should not be less than 20 cm. The pump handle shall be so designed that a complete stroke of the pump may be obtained with the pump handle turned to any position. The compression strength of the assembly, including the handle, its components, and its junction with the plunger rod, shall not be less than that of the plunger rod. Whatever the material used for manufacture, it must be non-absorbent.

1.8.7 Handle locking device

The plunger shaft shall be fitted with a quick-acting locking device that when applied will secure the plunger assembly nearest to its lowest operating position. A sample of the locking device shall withstand 1000 locking and releasing cycles without failure.

1.9 Tank outlet

The tank shall be fitted with an outlet to which a hose connection or pressure regulator device may be attached. If the outlet is at the tank top a dip tube shall be provided. The dip tube shall be constructed of brass, stainless steel or plastic not less than 0.92 mm $\pm$ 10% thick (20 gauge) and shall extend to within approximately 1.0 cm of the bottom of the tank. The end of the tube within the tank shall be cut at an angle of 45 degrees to prevent blockage. The dip tube shall be securely supported at the point where it emerges from the tank and at a point near its lower end within the tank.

If the outlet is at the base of the tank it shall be recessed or protected in such a way to withstand the drop test described in section 2.1.3. Base outlets shall be protected internally by a filter.

1.10 Strainers

One or two strainers may be provided. Two strainers shall be of equal dimensions located at different points easily accessible in the discharge line between the entry to the dip tube and the entry ports of the cut-off valve. If one strainer is provided it shall be located in the cut-off valve. The strainers shall be made of Monel, stainless steel, plastic, bronze or any material of equal or superior durability and non-corrosiveness.

The total open area of the strainer shall be not less than $10cm^2$. The strainer shall have sufficient structural strength, or shall be mounted in such a way, that it will not be subject to accidental puncture or collapse. It shall be easily removable and replaceable without special tools. Although it is preferable that the strainer should be simply pushed into place, a screw fitting may be used. Flow through the strainer shall be from the outer surface inward. A strainer confined in a tubular member shall

have not less than 2.5 mm clearance in the annular space. The strainer openings shall have no aperture greater than 0.5 mm in any direction.

1.11 Hose

Hose of general use shall be of natural or synthetic rubber or plastic and shall be resistant to the pesticide formulations or oils to be used, as specified by the purchasing agency. A length of 1.5 m with an inside diameter of not less than 9.0 mm shall be provided with each sprayer. The hose shall have one or more plies of reinforcement and made from cotton duck, cotton yarn, or synthetic fibre, of at least two-end yarn. The material shall be evenly and firmly woven and free from unsightly defects such as dirt, knots and lumps, as well as from irregularities or twist. The tube and cover shall be free from pitting and shall be uniform in thickness. The reinforcement shall be lapped (not sewn) at least 13 mm and shall be well frictioned on both sides with a rubber compound that shall firmly join the plies to the rubber tube and cover and to each other.

50 cm-long samples of the hose shall meet the following requirements:

(1)	Tolerance in inside diameter	0.8 mm
(2)	Breaking test:	
	initial, minimum	2800 kPa
	decrease after aging, maximum (section 2.5)	35%
(3)	Bursting strength under hydrostatic pressures:	
	initial, minimum (section 2.6.1.)	2800 kPa
	after immersion, minimum (section 2.6.2.)	1500 kPa
(4)	Swelling after immersion	20%
(5)	Expansion after 5 minutes under hydrostatic pressure of 1000 kPa and releasing pressure	Nil

In tensile strength the hose shall be capable of maintaining its length when a weight equal to three times that of the charged sprayer is applied for five minutes.

1.12 Hose connections

Hoses shall be retained on connections or couplings preferably by clamps or clips of the worm-drive type.[1] The connections shall have no sharp edges and a minimunm of extended projections liable to catch on clothing or other objects. Hose connections shall be deemed to have met strength requirements if they withstand a static hydraulic pressure test of 1000 kPa for a period of five minutes without evidence of leakage or structural failure following five applications and removals shall be made in series and at short intervals, both on new hoses and after a hose has been immersed.

Threaded terminal connections shall have finished, hexagonal faces or oposing flattened surfaces. Knurled faces or wing nuts of adequate strength and size may be permitted if couplings are fabricated to enable airtight and liquid-tight joints to be made by thumb pressure at the highest designated operating pressure. Threaded terminal connections are preferred.

1.13 Cut-off valve

1.13.1 Construction

All parts of the valve body shall be made of brass, bronze, stainless steel or plastic. The valves shall be so constructed that inner and outer parts are readily accessible for frequent cleaning without the use of special tools.

1.13.2 Connections

Valves shall be equipped with screw threads at inlet and outlet ports. The threads shall be compatible with the lance and nozzle body. The outer surface of the valve, adjacent to the screw threads, shall have opposing faces, to permit the use of a wrench, if tools are required for its removal. Knurled faces or wing nuts of adequate shape and size may be used provided that the valve can be loosened and tightened adequately by the pressure of thumb and fingers alone, without the use of tools, so that no leaks occur at the highest designated operating pressure.

1.13.3 Liquid passages

No liquid passages through which the entire liquid-volume must pass shall have a cross-section area of less than 0.25 cm^2.

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[1] Where plastic hose is specified, the hose connections may be of a type agreed upon between the purchasing agency and the manufacturer.

1.13.4 Valve handle

The handle shall be conveniently located on the valve to permit actuation by the hand. The valve handle and all associated parts shall conveniently fit the operator's hand without discomfort, and shall have no sharp edges or projections.

The torque required to move the handle on a lever-type valve from the closed to the open position shall not be more than 1.5 Nm. The length of the valve handle shall be not less than 10 cm measured from the pivot. The method used to determine the torque is described in section 2.8.

1.13.5 Leakage

A sample of cut-off valves shall not drip or leak through the valve or around the packing when subjected to:

(a) 500 cycles of operation at a pressure of 100 kPa
(b) 50 000 cycles of operation at a pressure of 500 kPa, and
(c) 500 cycles of operation at a pressure of 1000 kPa

in accordance with the test described in section 2.9.

After this test the valve shall not drip or leak throughout the pressure range of 0-1000 kPa.

1.14 Lance

1.14.1 Description

The lance shall be of seamless construction and shall be easily detachable. It shall have the same thread and size at both ends so that any number of lances in series, or the nozzle alone, can be connected directly to the cut-off valve housing. Joints shall be leakproof and body facings shall have hexagonal or flattened faces. Knurled faces or wing-nuts of adequate shape and size may be permitted if couplings are fabricated to enable airtight and liquid-tight joints to be made by thumb pressure at the highest designated operating pressure. A gasket may be used to ensure a tight fit. The inside diameter of the tube shall be not less than 6 mm. Standard lances shall be between 40 and 50 cm in length, measured between the external faces of the joints. At the option of the purchasing agency, lances able to be stored in the tank during transport may be specified.

1.14.2 Strength

The strength of the lance and its joints shall be such that it will meet the test described in section 2.10.

1.15 Nozzle assembly (flat fan jets)

1.15.1 Description

The spray nozzle shall be of the hydraulic-energy type in which droplets are formed by forcing the spray material through an orifice. The nozzle assembly shall consist of a droplet-producing nozzle tip plus a nozzle body and nozzle cap. Nozzle filters may be specified by the purchasing agency. At the option of the purchaser, gaskets of polyethylene or other materials may be used.

1.15.2 Materials of construction

The nozzle body and cap shall be of nonferrous metal or plastic material. The tip shall be of stainless steel, ceramic, plastic, or other suitable material.

1.15.3 Dimensions

The nozzle assembly should be compatible to the lance connecting thread which shall be 1/4 in NPT.[1] (or the nearest equivalent national standard as stipulated by the purchasers).

1.15.4 Weight

The weight of the nozzle assembly (tip, body, filter and cap) shall not exceed 70 g.

1.15.5 Performance of the nozzle tip

1.15.5.1 Initial performance

(a) Initial discharge rate.

The discharge rate of the tip shall be as specified by the user agency.[2] Tolerance limits of the initial discharge rate shall not exceed $\pm$ 4% when tested in accordance with the procedure described in section 2.12.

(b) Initial distribution pattern.

The nozzle tip shall deliver a flat fan-shaped spray, the two sides of the fan forming the angle specified by the purchaser.[3] It shall maintain a uniform distribution throughout the entire pattern, giving an even coverage across at least 80% of the swath width (plateau); the side portions of the pattern shall have even slopes without peaks when tested as described in section 2.11.

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1 National (USA) pipe thread.

2 For residual spraying, nozzle tips that discharge 757 ml/min (0.2 US gal/min) at the specified pressure are normally required. The pressure shall be specified by the purchasing agency.

3 For residual spraying, nozzle tips giving an 80° fan at 280 kPa are normally required. When used in combination with the disc flow regulator, tips with a greater angle and discharge rate may be needed.

1.15.5.2 Standard erosion performance

The nozzle output shall not increase by more than 10% after being subjected to the test described in section 2.15. Nozzle tips of various types suitable for residual spraying shall be tested in accordance with type procedures described in section 2.15. The purpose of this test, which will be carried out in reference laboratories, is to determine the changes in performance due to erosion of nozzle tips under identical and standardized conditions. The results of the test will guide the purchasing agencies in selecting the most suitable nozzle tips for a programme. The test will continue until the distribution pattern deteriorates beyond the limits specified below.

(a) Discharge rate. The discharge rate will be measured at intervals as described in section 2.12.

(b) Distribution pattern. The distribution pattern will be determined at intervals as described in section 2.11. the pattern is unacceptable when:

(i) the width of the plateau is less than 65% of the base;
(ii) the peaks and valleys in the distribution pattern across the plateau exceed + 30% of the plateau height;
(iii) the pattern has uneven slopes with peaks reaching the plateau.

1.16 Gaskets and seals

Where possible all gaskets or seals shall be partially or wholely recessed where fitted but should be capable of being readily fitted to the sprayer. All seals and gaskets shall be capable of operating satisfactorily after the immersion test described in section 2.13.

It should not be possible to extrude the gasket or seal from its position by overtightening.

1.17 Optional items

The following items may be included in the order at the option of the purchasing agency.

1.17.1 Air-inlet valve

An air-inlet valve (automobile type) may be provided for the purpose of supplying air pressure to the sprayer from an outside pump or high pressure source. With such an inlet valve a highly reliable pressure-relief (safety) valve shall be required (see section 1.17.2).

1.17.2 Pressure-relief (safety) valve

An adjustable pressure-relief valve shall be provided whenever an air-inlet valve is requested, to prevent pressurization in the tank beyond the limits prescribed for safety or operational purposes.

1.17.3 Regulated delivery system

A regulated flow-delivery system, consisting of a complete nozzle assembly and disc flow regulator may be supplied. When the unit is new the discharge rate and distribution pattern shall be as specified by the purchasing agency. A tolerance limit of $\pm$ 4% may be allowed on the specified discharge rate. The pattern shall meet requirement (b) in section 1.15.5.2. The performance of the unit in use shall be tested and shall comply with the specification given in section 1.15.5.

1.17.4 Constant-pressure regulator

The sprayer may be equipped with a constant-pressure regulator inserted in the discharge line, adjustable to produce tip pressures in the programme operating range, as specified by the purchasing agency. The tolerance shall be not more than $\pm$ 20 kPa.

1.17.5 Lances

Extra lances may be ordered for use as extensions. These may be the same length as the regular ones, or any other length specified by the purchaser.

Leakproof telescopic lances may be provided at the request of the purchasing agency. In the collapsed state the length shall not exceed that specified in section 1.14.1.

1.17.6 Swivel nozzles

Leakproof swivel nozzles that can readily be rotated by hand may be provided.

1.17.7 Gooseneck attachment

A gooseneck attachment may be provided consisting of a section of lance, curved 120^{o}, with a 20 cm length of tubing, conforming to section 1.14 of this specification, with a coupling on each end to permit attachment to the lance and nozzle body.

1.17.8 Nozzle gaskets

Gaskets of polyethylene, or equivalent material, not less than 0.08 cm thick, may be provided in such places and number in the nozzle body as required to allow the unit to be easily and quickly disassembled and assembled without tools. The unit assembled in such a manner shall not leak when there is flow through the nozzle at maximum working pressure.

1.18 Spare parts

A supply of spare parts is required for each sprayer delivered (to be specified and itemized by the user, based on his knowledge of parts most likely to need replacement during normal use of the sprayers over a given period of time). Spare parts are to be packed separately and provided for each sprayer according to the number required by the purchasing agency.

1.19 Operation and maintenance manual

An adequately illustrated manual of compression sprayer operation, maintenance, and repair, in the language specified by the purchasing agency, shall be provided by the manufacturing company. The number of copies of the manual to be supplied with each order is one for 1-4 sprayers, two for 5-8 sprayers, three for 9-12 sprayers, etc. The manual shall include a complete list of regular and optional parts, instructions for disassembly and cleaning, instructions for routine inspection, adjustments, and replacement of parts, instructions for handling the sprayer, and instructions for using the sprayer with insecticides.

1.20 Inspection, sampling and testing

Inspection, sampling and testing shall be performed in accordance with the procedure outlined in Annex 2 of WHO publication Equipment for Vector Control, 1974.

1.21 Field performance and durability test

The sprayer should successfully undergo a field trial for a period of 450 hours without change in specification provided by the manufacturers and development of major and/or frequent breakdowns of any part(s) of the sprayer. The field trial shall be performed in accordance with the guidelines for field trials of the hand-operated compression sprayer.

2. TEST PROCEDURES[1]

The test prodecures recommended in this specification are not intended to exclude accepted equivalent methods that may be in use in different countries. However, in the event of disagreement, the prodecures described herein shall govern. All pressure tests must be carried out with a safety screen to protect the operator.

2.1 Tank leakage test

The tank with all its fittings attached except the pressure gauge shall be filled completely with water and coupled to a hydraulic pump. The tank shall be subjected for one minute to twice the maximum working pressure, or not less than 1000 kPa. The sprayer fails the test if it is permanently distorted or any leakage occurs. Caution must be exercised during the pressure test, and the operator must use a safety cage.

2.2 Tank fatigue test

Although the distortion is not readily perceptible to the eye, a compression-sprayer tank bends outwards when the tank is pressurized, returning to a normal position when pressure in the containers returns to that of the atmosphere. Repeated pressurizations, as are encountered by equipment in field use, result in a bending back and forth of surfaces. Fatigue failure frequently results; the first evidence of this is usually seen in a broken or leaking weld or a crack radiating from an opening such as that designed to receive the cover or pump.

Fatigue stress may be simulated by the apparatus shown in Fig.1. The dip tube connection of each tank is connected to the manifold by means of a copper tube or a rubber hose, preferably the sprayer hose. A small angle-valve is provided at each point of connection with the manifold in order that any connection may be closed off as desired.

The tank under test shall be filled completely with water; the top and any other openings shall be closed, and the manifold filled with water to a point within approximately 20 cm of the filler hole. The water level may be checked at filling or during testing by observing from which of the three vent fittings water will flow upon opening.

Compressed air shall be introduced into the manifold through a pressure-regulating valve and an electrically operated 3-way valve. A timer cam switch, driven by a small electric motor, opens and closes the 3-way valve four or more times a minute. When electric energy is applied to the 3-way valve, compressed air

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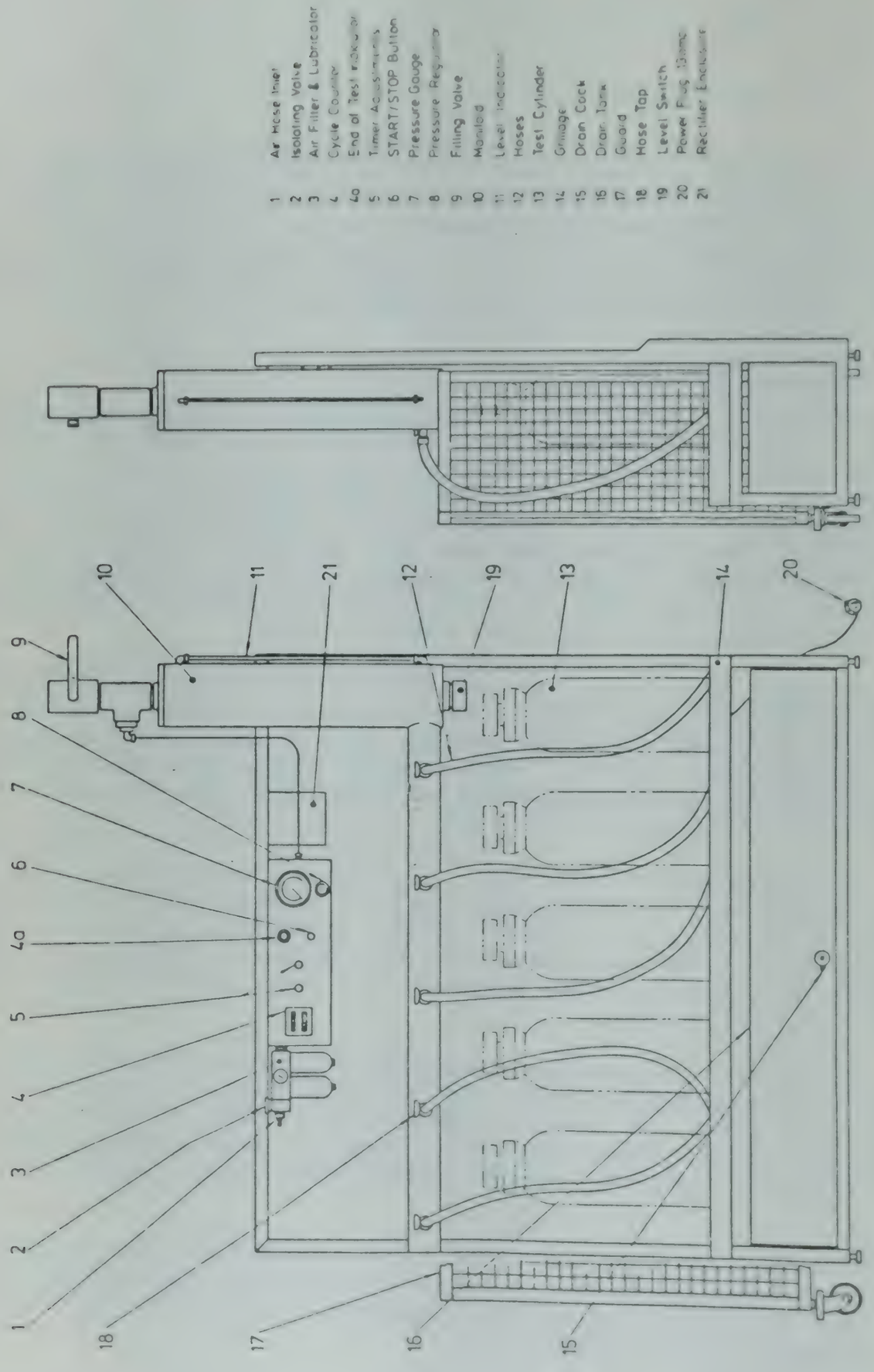
[1] **CAUTION:** It will be noted that several of the tests are performed under pressure. In these cases, every precaution should be taken to prevent injury to personnel or damage to surroundings in the event of an explosion.

FIG 1. TEST APPARATUS FOR DETERMINATION OF FATIGUE FAILURES IN COMPRESSION SPRAYER TANKS



flows from the source into the manifold at a pressure determined by the setting of the regulating valve. When the valve is de-energized, the air flows out of the manifold to the atmosphere. The result is that pressure is applied intermittently to the water in the manifold which, in turn, transmits the pressure to all parts of the sprayer.

An electrically operated counter is connected in parallel with the terminals of the coil of the solenoid valve. Consequently, each time the valve is energized to accomplish a pressure cycle, the counter registers the fact and thus indicates the total number of pressure cycles accomplished.

The counter may be omitted and the performance based on the total time during which the sprayers are subjected to the test at a fixed pressure and rate of operation. Alternatively, fatigue stress may be simulated by neumatically controlled apparatus using pneumatic timers, valves and counters incorporating a low voltage fail safe isolating valve actuated by a level switch in the reservoir. Should the sprayer on test fail or leak the test rig should automatically shut down and clearly indicate the number of cycles completed.

2.3 Tank impact (drop) test

A platform consisting of planed solid oak or similar wood, 5 cm thick and 90 cm square, shall be placed on a level cement, stone, or hard-packed earth floor. The tank to be tested, three-quarters filled with water and pressurized to maximum working pressure shall be held in one of the positions shown in Fig. 2 and then allowed to drop in a free fall from a height of 60 cm on to the platform. This will be repeated in the manner and for 24 times as indicated in the figure. Caution should be exercised in performing this test to avoid possible injury due to explosion of the tank. A metal cage must enclose the tank during the drop test.

2.4 Strap drop test

The straps, strap clips, and strap-hangers shall be tested for the strength of the whole assembly. The tank shall be filled to two-thirds of its total liquid and air volume and the pressure raised to maximum working pressure. The sprayer shall then be hung from a solid support by its strap, simulating its carriage on the shoulder of an operator. It shall be lifted a distance of 30 cm and allowed to drop freely and hang by the strap 25 times. The assembly shall be deemed to have failed to meet the requirements of this test if any part of it or its fittings breaks or becomes permanently deformed, or if the tank develops leaks. Leaks shall be determined by draining the tank of water and checking for air leakage by immersing the tank in water while pressurized at an internal pressure of 400 kPa.

2.5 Hose aging test

Samples should be 50 cm long. The sample to be tested shall be placed in an oven at a temperature of 78°C ± 1°C. The sample shall be so suspended that it does not come into contact with any metal portion of the oven or other apparatus. After 48 hours the sample shall be removed and subjected to the appropriate test (see section 1.11, requirement (2)).

2.6 Hose hyrostatic pressure test

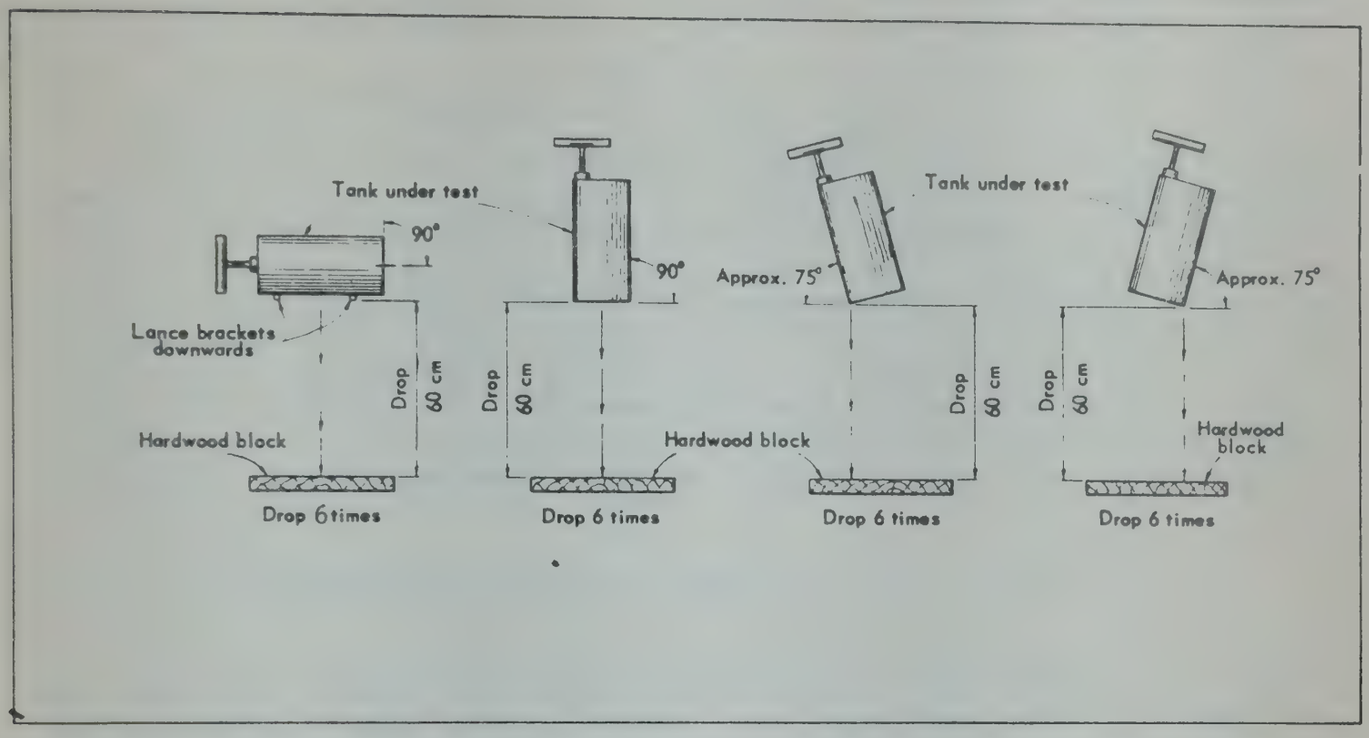
2.6.1 Before immersion

Samples of hose not less than 50 cm in length shall be coupled to a hydraulic pump. Water shall be pumped through the tube. While the tube is full of water, the open end shall be closed with a metal plug and secured with a compression clamp. The full indicated burst pressure shall be applied to the hose in a period of not more than five seconds.

2.6.2 After immersion

Samples not less than 50 cm long shall be completely immersed in a mixture of 40% kerosene, 20% toluene, and 40% xylene. Care should be taken to avoid formation of air pockets inside the tube and to keep the sample from contact with the surface of the container. The sample shall be immersed for a period of 72 hours at a temperature of 21° - 27°C, after which it shall be dried by hanging in the air at 21° - 27°C for 24 hours. The test described in section 2.6.1 shall then be performed on the sample.

FIG. 2. IMPACT (DROP) TEST FOR COMPRESSION SPRAYER TANKS



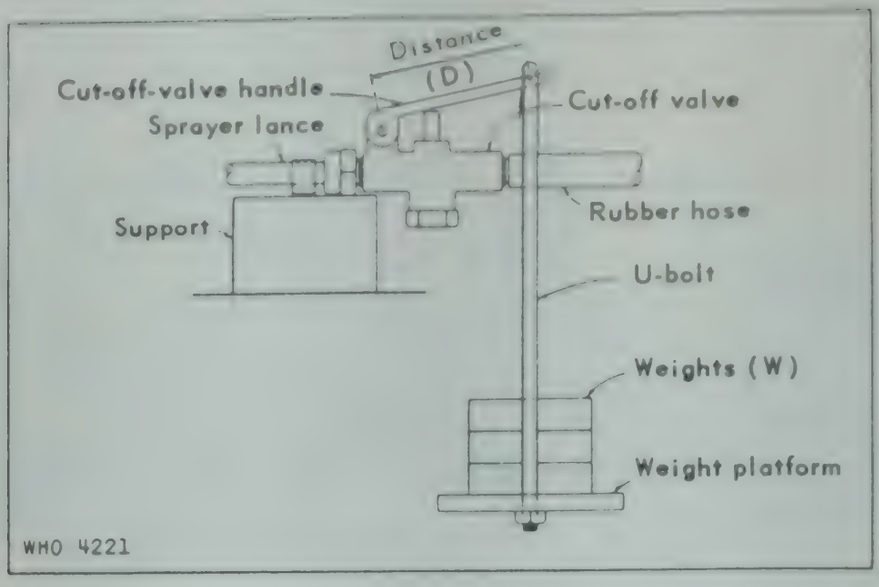
2.7 Hose swelling test

Swelling shall be determined by measuring the inside and outside diameters of the sample before and after immersion. The method of immersion shall be that specified in section 2.6.2. The hose shall meet the requirement specified in section 1.11 (requirement 4).

2.8 Cut-off valve handle actuation tests

The method of measuring the torque required to activate the cut-off valve is shown in Fig.3. The torque is equal to the weight (W) required to move the lever from the closed to the open position multiplied by the distance (D) from the point of application of the weight to the pivot point of the lever.

FIG. 3. METHOD OF MEASURING THE TORQUE REQUIRED TO ACTUATE A CUT-OFF VALVE



2.9 Cut-off valve reliability test

The valve shall be rigidly mounted and operated by a cam and cam follower, as shown in Fig. 4. When operated by a cam of this design under 500 kPa hydraulic pressure (applied to the valve faces), a typical valve will open and close in accordance with the curve in Fig. 5(A). This action is a satisfactory reproduction of the opening and closing characteristics of a hand-operated valve as shown in Fig. 5(B). The test liquid shall consist of either (1) a mixture of 40% kerosene, 20% toluene, and 40% xylene, or (2) a 5% suspension of an inert powder. The former is used to impose the maximum demand on nonmetal parts; the latter will test the abrasion resistance of the metal parts of the valve and will reveal any tendencies towards stoppage of the liquid passages. The test liquid shall be applied to the inlet of the valve under a static pressure of 500 kPa.

The outlet of the valve shall be carried through a spray nozzle designed to deliver approximately 0.75 litres per minute at 350 kPa. The nozzle may discharge directly or through appropriate piping into a reservoir from which the liquid is returned under pressure to the inlet port of the valve. The test mixture shall be changed after every 48 hours of use, and the test suspension after every eight hours of use. The testing apparatus shall be so arranged that the valve mechanism is actuated not more than 15 times per minute. The mechanism shall open the valve in not less than 0.1 seconds and not more than 0.2 seconds. After an initial test of 500 cycles at 100 kPa, the test will continue for

50 000 cycles of operation at 500 kPa, finally the test is repeated with the input pressure to the valve set at 1000 kPa for 500 cycles. Alternatively pneumaticaly controlled test apparatus can be used using pneumatic timers, valves and counters. The test rig should shut down if the valve under test fails and indicate the cycles completed.

2.10 Lance strength test

The lance shall be attached to the cut-off valve by its normal fastenings and the cut-off valve mounted in a bench vice in such a manner that the lance projects horizontally. The nozle body is removed. A weight of 2kg is dropped 8 cm to hang from the end of the lance just behind the outer nozzle coupling. When the weight and lance have come to rest, the weight is removed an the lance is rotated 180^{o}. The weight is dropped a total of 20 times with 180^{o} rotation of the lance between successive drops. After completion of this procedure, the lance and its connections shall not leak, bend excessively or be otherwise unusable under normal operating conditions.

2.11 Liquid-volume distribution test

The nozzle shall be held 45 cm over a corrugated metal tray so that the volume of liquid discharged in each channel, normally 2.5 cm wide, shall be collected in a separate container and the volume plotted on graph paper to from a histogram showing the volume distribution. Amounts less than 1 ml at the ends of the spray base shall be omitted from the performance test. At least 0.5 litres of spray shall be applied during this test, or the nozzle operated for one minute.

An apparatus that has been found suitable for performing this test is shown in Fig. 6.

2.12 Test apparatus

For accurate nozle liquid discharge rate tests an apparatus should be set up consisting of the elements shown in Fig.7.

2.12.1 Test apparatus

A manually-powered source of compressed air can be used, but a power-driven sources is highly desirable.

Small balanced-diaphragm pressure regulators (2) may be used. They should be readily adjustable by turning a knob.

FIG. 4. TEST APPARATUS FOR DETERMINATION OF THE RELIABILITY OF CUT-OFF VALVE

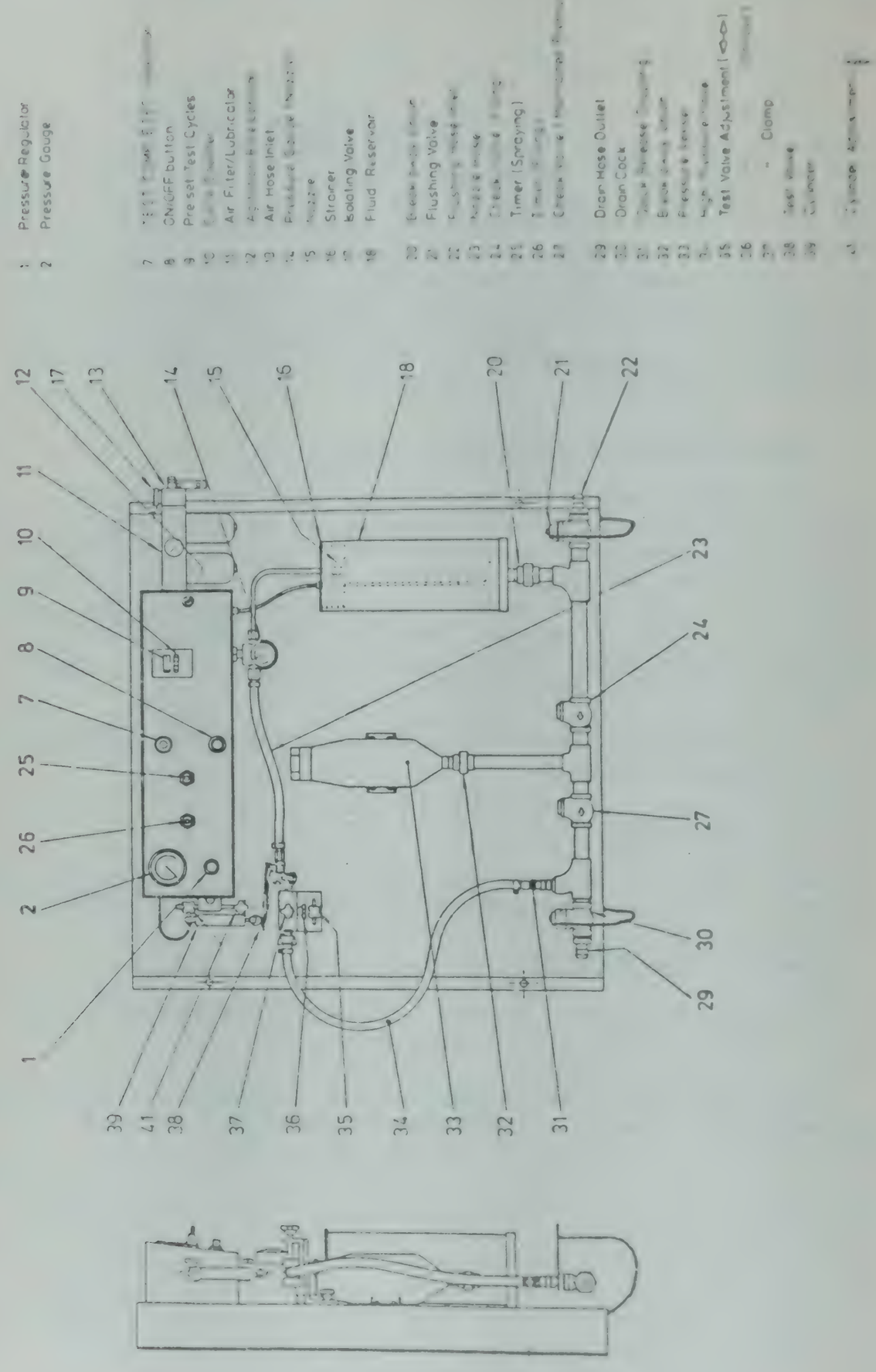
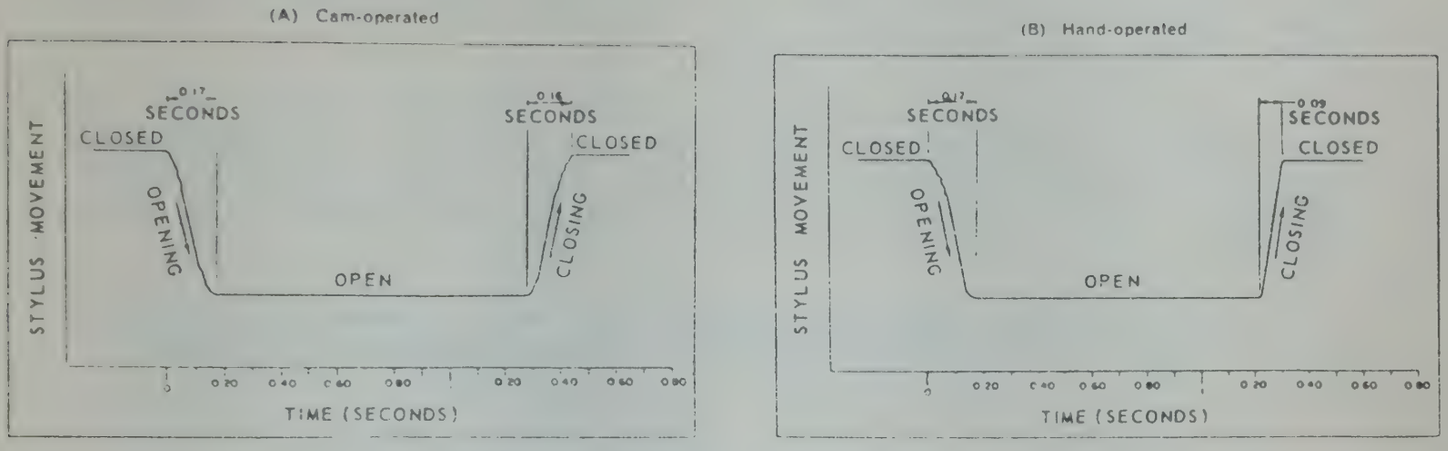


FIG. 5. ANALYSIS OF MOVEMENT OF CUT-OFF VALVES



Both the air reservoir (3) and water reservoir (4) may be compression sprayer tanks. The air reservoir contains no water. The water reservoir is filled to the top and refilled when empty.

The solenoid valve (5) should be the single channel type (normally closed) capable of on/off operation at 560 kPa. Its electric coil should be designed to operate on the local voltage and frequency.

The pressure gauge (6) should be frequently calibrated against a standard. Mounted on it should be a buzzer, connected through a voltage-reduction device, to the time. The buzzer is intended to cause vibration of the gauge and prevent the needle from sticking.

The timer (7) may be of the photographic or industrial type that can be set to 30 or 60 seconds and the adjustment secured in place so that it cannot readily be disturbed. It should have an accuracy of $\pm$ 0.1 seconds.

The nozzle body (8) should be arranged for quick and easy changing of the tips or other types of nozzle under test.

2.12.2 Test procedure

The nozzle tip to be calibrated is placed in the nozzle body (8). With the timer off and the solenoid valve closed, the regulator (2) is adjusted to show a pressure on the pressure gauge (10) of 70 kPa above the pressure to be used in the test. The timer (7) is actuated, opening the valve (5) and allowing water to flow through the nozzle tip. The regulator (2) is adjusted to give the exact test pressure on the gauge(6). The timer is shut off and the empty measuring cylinder (9) placed under the nozzle. The timer is turned on and flow through the nozzle allowed for the 30- or 60-second period. During the entire period of flow the

regulator (2) must be manually adjusted to keep the pressure shown on (6) at the selected level. At the end of the period, the timer will turn off automatically, the solenoid valve will close, and flow through the nozzle will stop.

The flow through the nozzle for the standard period will be measured by determining the volume of water in the measuring cylinder to the bottom of the miniscus. For more accurate results, the weight of the water may be determined on a good balance.

The procedure may be repeated as many times as desired, always using the same time period and without changing the timer.

FIG. 6. TEST APPARATUS FOR DETERMINATION OF LIQUID-VOLUME DISTRIBUTION PATTERN OF NOZZLES

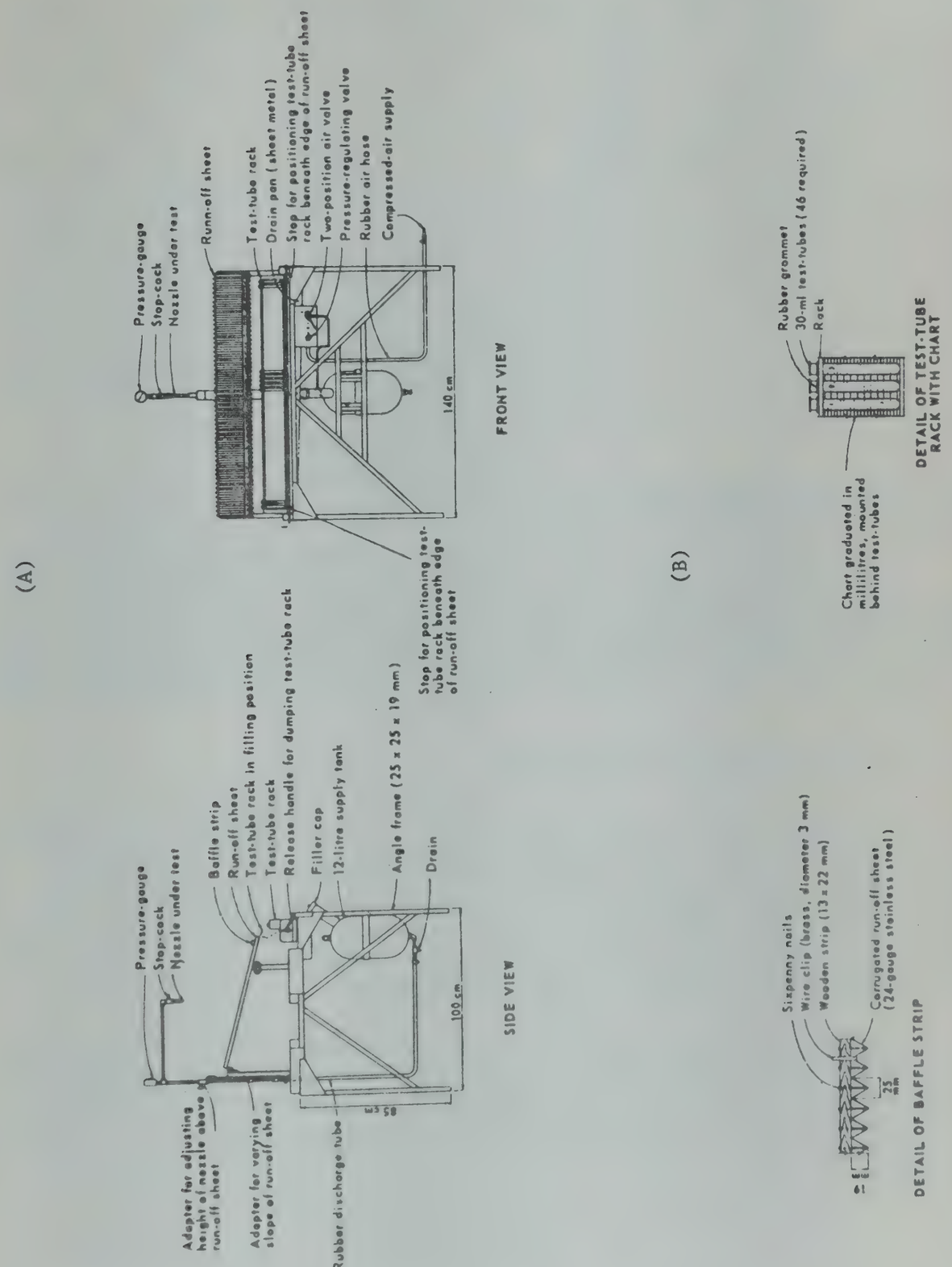
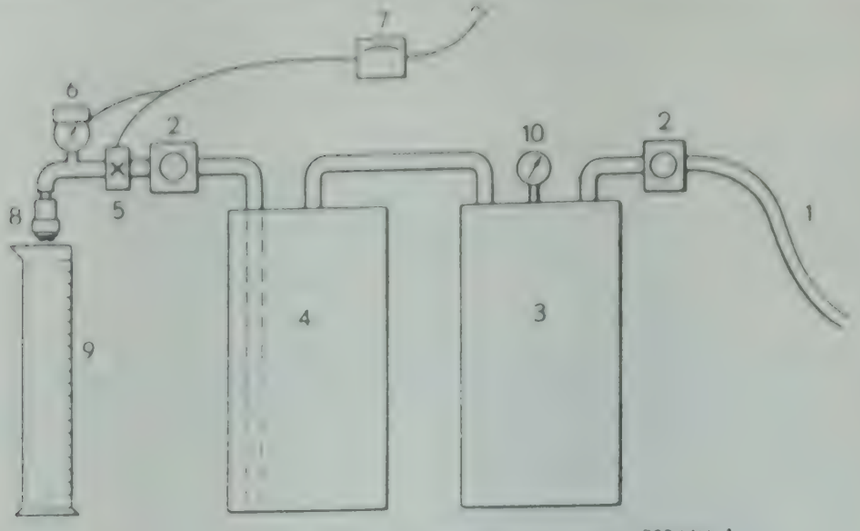


FIG. 7. APPARATUS FOR LIQUID DISCHARGE RATE TEST



1 Air hose to source of compressed air, 700 kN/m².
2 Pressure regulator, balanced diaphragm type
3 Air reservoir (may be empty compression sprayer tank).
4 Compression sprayer tank filled with water.
5 Electrically operated valve in pipeline
6 Calibrated pressure gauge, 0–560 kN/m², with electric buzzer mounted on it
7 Electric timer with an on cycle of 30 or 60 seconds ±0.1 second.
8 Nozzle body and tip under test
9 500-ml or 1000-ml measuring cylinder.
10 Pressure gauge, 0–700 kN/m².
~ = connexion to main electricity supply.

2.13 Gasket immersion treatment

The gaskets shall be removed from the equipment and immersed in a mixture of 40% kerosene, 20% toluene, and 40% xylene for a period of 72 hours at a temperature of 21-27°C, and then dried by hanging in air at 21-27°C for 24 hours. The gaskets shall then be replaced in their original positions on the equipment (see section 1.16).

2.14 Tests for pressure gauges

The pressure gauges should be tested for accuracy, reliability and durability. Samples of gauges supplied with sprayers shall be tested for accuracy by assessing their performance in comparison with standard valid gauges. The range of error shall not exceed ± 5% at any pressure. The range of pressure to be applied shall be that indicated on the gauge dial, or as specified by the purchasing agency.

Durability and reliability of gauges shall be tested, if possible, under stimulated field conditions. This is done during the tank-fatigue test. At the end of the test, the accuracy of the gauge should be checked as stated above. The maximum permitted error in the gauge readings is ± 10% of the true pressure.

2.15 Standard nozzle tip erosion performance test

2.15.1 Abrading material

The abrading material shall be a synthetic silica powder with the following chemical and physical properties:

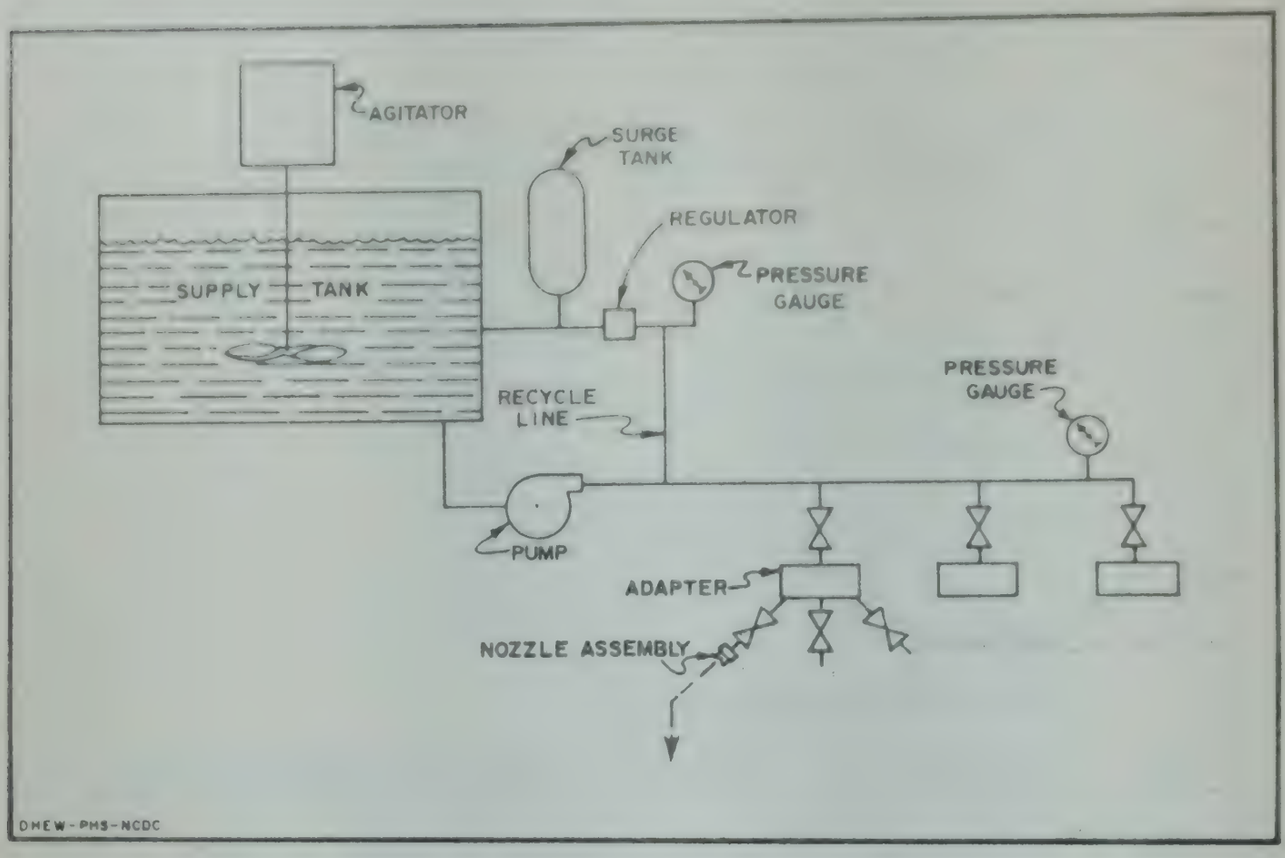
Bulk density:	160 kg/m^3
Specific gravity:	1.95
Average particle size:	0.022 um
Colour:	white
Refractive index:	135-165 Gardner-sward test units.
Surface area:	140-160 m^2/g
pH (5% water suspension):	7.3
Loss at 105°C:	5%
Loss at 1200°C:	10%
SiO_2 content:	87%
CaO content:	0.5%
Fe_2O_3 content:	0.2%
Al_2O_3 content:	0.6%
$NaCl$ content:	1.0%

2.15.2 Abrading suspension

The abrading water suspension shall contain 20 g of the abrading material per litre and the suspension shall remain uniform throughout the test.

The nozzle shall be placed in a test apparatus (as shown in Fig. 8) so that it shall spray the test liquid at 300 kPa for 20 hours. Discharge rate of the nozzle can be checked at 0, 2, and 20 hours.

FIG. 8. EQUIPMENT FOR TESTING NOZZLE TIP-ABRASION



The pattern of the nozzle should not be significantly affected by this test and should be checked as described in section 1.15.5.1.

CONVERSION FACTORS

Length

1 micrometre (um)	=	0.0000394 inches (in)
1 centimetre (cm)	=	0.394 in
1 metre (m)	=	39.36 in
	=	3.281 feet (ft)
	=	1.094 yards (yd)
1 kilometre (km)	=	0.6213 miles, statute (mi)

Weight

1 gram (g)	=	0.0353 ounces, avoirdupois (oz)
1 kilogram (kg)	=	2.205 pounds (lb)
1 tonne, metric	=	1000 kg
	=	2205 lb
	=	0.984 tons, English
	=	1.102 tons, USA

Area

1 cm^2	=	0.155 in^2
1 m^2	=	1549 in^2
	=	10.76 ft^2
	=	1.196 yd^2
1 hectare (ha)	=	10 000 m^2
	=	11 960 yd^2
	=	2.471 acres (ac)
1 km^2	=	100 ha
	=	247 ac
	=	0.386 mi^2

Volume

1 millilitre (ml)	=	0.061 in^3
1 litre (l)	=	61.023 in^3
	=	0.0353 ft^3
	=	33.8 fluid ounces (fl.oz) USA
	=	35.2 fl.oz, Imperial (Imp)
	=	0.264 gallons (gal), USA
	=	0.220 gal, Imp
1 m^3	=	1000 litres

Velocity

1 metre/second (m/s)	=	3.60 kilometres/hour (km/h)
	=	2.24 mi/h
1 km/h	=	0.62 mi/h

Force

1 newton (N)	=	0.1019 kgf
	=	0.2248 lbf

Pressure

1 kilo Pascal (kPa)	=	1 kilonewton per square metre (kN/m^2)
	=	0.0102 kgf/cm^2
	=	0.145 lbf/in^2

Application rate

1 kg/ha	=	0.892 lb/ac
1 l/h	=	0.107 US gal/ac
	=	0.089 UK gal/ac
	=	13.70 US fl.oz/ac
	=	14.24 UK fl.oz/ac

Temperatures

°C	°F	°C	°F
10	50.0	36	96.8
12	53.6	38	100.4
14	57.2	40	104.0
16	60.8	42	107.6
18	64.4	44	111.2
20	68.0	46	114.8
22	71.6	48	118.4
24	75.2	50	122.0
26	78.8	52	125.6
28	82.4	54	129.2
30	86.0	56	132.8
32	89.6	58	136.4
34	93.2	60	140.0

ANNEX 3

EXAMPLE OF A DATA SHEET ON PESTICIDE APPLICATION EQUIPMENT
No. E.1

Name and Model: Trademark/Commercial Code

CLASSIFICATION:

Type: compression sprayer, hand-operated
Use: surface spraying and larviciding with liquid pesticide formulations

1. GENERAL INFORMATION

1.1 Shape ☐ cylindirical ☐ cubical ☐ curved

1.2 Dimensions*:

diameter of tank - in cm
height of tank - in cm
height of sprayer- in cm

1.3 Capacity*

total (liquid and air)	in litres
liquid only	in litres

1.4 Weight*/(empty) in kg.

2. TANK

2.1	Material of construction	indicate the alloy
2.2	Type of sealing	indicate type(s)
2.3	Marking for liquid volume*	in litres (indicate the no of levels)
2.4	Maximum working pressure*	in KPa
2.5	Maximum pressure tolerance	in KPa
2.6	Dimensions* of filler opening	in cm

* Results of tests recommended in specifications WHO/EQP/1.R4 are to be attached.

2.7 Pressure gage:

type ☐ mechanical ☐ other (specify)
scale reading ☐ KPa ☐ PST ☐ 1st

2.8 Pressure-release device ☐ valve ☐ push botton

2.9 Shoulder straps:

number
material quality of texture
dimensions lenght cm, width cm, thickness cm

2.10 Fastenings for hose

type ☐ clips ☐ etc
number

2.11 Foot rest:

type material of construction and shape
bearing area in cm²

3. **AIR PUMP**

3.1 Dimensions of the pump cylinder - length in cm
diameter in cm

3.2 Material of construction type of alloy

3.3 Type of sealing describe in detail

3.4 Number of full pump strokes to produce maximum working pressure

3.5 Type of check valve describe in detail

3.6 Plunger shaft:

type (solid/hollow) mark the relevant
material type of alloy
dimensions length in cm width in cm

3.7 Stop spring:

material describe the alloy
dimensions length in cm -diameter in cm -thickness in cm

3.8 Dimensions of rubber bumper

3.9 Plunger cup:

material ☐ synthetic ☐ rubber ☐ leather
dimensions

3.10 Plunger cup spreader:

material describe type of material
dimensions diameter cm - thickness cm

3.11 Pump handle:

type ☐ T shape ☐ D shape ☐ flat ☐ tubular
material ☐ metal ☐ wood ☐ synthetic
dimensions length in cm - diameter in cm

3.12 Type of pump handle locking device

describe material, type and placement

4. DISCHARGE SYSTEM

4.1 Dip tube:

material type of alloy and sealing
dimensions length in cm - diameter in cm

4.2 Strainers:

number indicate
material ☐ metal ☐ synthetic
total open area of each cm²
aperture of openings cm mesh size

4.3 Hose:

material ☐ rubber ☐ synthetic
☐ resistant to chemical
length in cm
inside diameter in cm

4.4 Type of hose connexions indicate

4.5 Cut-off valve:

type indicate
material ☐ metal ☐ synthetic

4.6 Type and length of handle of cut-off valve

indicate type, material and dimensions cm

4.7 Lance:

material indicate alloy
length in cm
inside diameter in cm

4.8 Nozzle assembly:

weight in grams
material of body and cap ☐ metal ☐ synthetic

4.9 Nozzle tip:

material ☐ metal ☐ synthetic
discharge rate at average working pressure in ml/minute
type of spray pattern ☐ fan ☐ cone ☐ jet
angle of spray degree
particle size VMD

5. **OPTIONAL ITEMS**

5.1 Air-inlet valve, type ☐ No ☐ Yes (describe)

5.2 Pressure-relief (safety) valve, type
☐ No ☐ Yes (describe)

5.3 Regulated flow-delivery system, type
☐ No ☐ Yes (describe)

5.4 Constant-pressure regulator, type
☐ No ☐ Yes (describe)

5.5 Extra lances, lengths
☐ No ☐ Yes (describe)

5.6 Swilve nozzles, type
☐ No ☐ Yes (describe)

5.7 Gooseneck attachment, angle and length of tubing
☐ No ☐ Yes (describe)

6. **SPARE PARTS**

Recommend spare parts to be provided with each unit
☐ No ☐ Yes

if ☐ Yes in kits ☐ on demand ☐

7. **TOOLS**

Recommend type and number of tools supplied per number of spray pumps purchased
☐ No ☐ Yes

if ☐ Yes describe No. and Type

8. **PUBLICATIONS** (samples to be attached) ☐ No ☐ Yes

8.1 Manual of operations, language used ☐ No ☐ Yes

8.2 Manual of maintenance, language used ☐ No ☐ Yes

8.3 List of spare parts, names and code numbers

☐ No ☐ Yes

Name and address:
(manufacturer's)

Date completed:

ANNEX 4

Example of a specification which is one of the priorities for FAO to develop and publish

SPECIFICATION FOR A LEVER-OPERATED KNAPSACK SPRAYER

Description

The sprayer shall consist of a tank equipped with hand operated pump, pressure chamber, filter hose, tap and boom with nozzles as specified. It shall be constructed in knapsack form to sit and balance comfortably on the operator's back. The sprayer with fittings assembled shall have no sharp edges or projections that might cause injury during normal operation. The top of the tank should be designed to avoid collection of spray. An agitator should be fitted.

Materials of Construction

The tank, including bottom, sides, top and removable filler-hole cover shall be made of chemical resistant material. If metals are used, all joints shall be welded or brazed, so that the joints shall have a tensile strength at least equal to that of the parent metal. Plastics or other materials may be used providing they comply with all other relevant specifications. With the exception of the handle of the pump, no wooden parts shall be used in the construction of the sprayer or the component parts thereof. All threaded connections and all joints shall be leak-proof without the use of cements, shellac or chemical binders of any kind.

Capacity

The recommended nominal capacity of the tank shall be between 12 and 18 litres.

Dimensions

The tank shall have an overall measurement not exceeding a width of 450 mm.

Weight

The basic weight of the sprayer when empty and without lance, boom, hose or tap, but complete with pump, lid, strainer, agitator and straps, shall not exceed 7.5 kg.

Tank

Leakage

The tank equipped for operation shall withstand without leakage the test described in Appendix A, both before and after the test for fatigue resulting from the action of the pump. (See also Appendix D).

Strength-impact (dropping)

The sprayer equipped for operation shall be dropped 25 times as specified in Appendix B and retested as in Appendix A.

Markings

The tank should be clearly marked to indicate the level of the liquid contents as required by the purchaser.

Tank fittings

Fastenings for boom

The tank should be fitted with an adjustable attachment for any special boom (e.g. tail boom) as specified by the purchaser.

Straps

General: Two straps made of plastic or uniformly woven material being free from defects and joints and made of non-absorbent material, shall be provided. If made of woven material, they shall have straight and firmly woven selvedges. Each strap shall not be less than 38 mm wide across the shoulder, 2 mm thick and 810 mm long, measured to the end of the clips, and shall be made to avoid rolling or stringiness. There shall be provision for ready adjustment in length. Suitable non-absorbent padding may be fitted to the strap. The tensile strength of the strap shall be not less than 225 kg. Straps and fittings must have an equal strength and must not break or become permanently deformed when subject to the tests specified in Appendix B & C.

Strap hangers: Each tank shall be provided with two or more strap hangers fastened to the sides of the tank or frame. Where strap hangers are an integral part of the tank or frame, they must have adequate strength to pass the strap test (Appendix C).

Strap clips: Each end of the strap shall be provided with a clip adequately fastened to permit ready removal from adjustment and attachment to the strap hangers. One strap shall be provided with a clip or hook for rapid removal of the sprayer from the operator's back, while the other shall be adjustable, but fixed to the sprayer.

Filler hole

The filler hole shall not be less than 95 mm across the smallest dimension. It shall have no sharp edges. The filler hole shall be fitted with a removable strainer (see section 10) and a closure which shall be easily removed and refitted so that a water-tight seal is readily formed around its circumference.

The closure should be designed to avoid collection of spray (see Section 1) and be provided with a central aperture not greater than 0.245 cm. The filler hole shall be designed to allow complete emptying of the tank, unless a separate drainage hole is provided.

Pump

Construction

The pump may be either a piston or diaphragm type pump operated by either right or left hand by means of an overarm or underarm lever. The pump chamber shall be of a chemical resistant material and shall withstand internal and external application of twice the working pressure plus 0.34 bar without structural failure. If a piston pump, the open end of the cylinder should be cone-shaped to facilitate replacement of the plunger cup. The pump and valves shall be designed to allow easy accessibility of all parts to facilitate maintenance.

Capacity

The pump shall be so designed to be capable of a throughput of not less than 100 litres per hour at a working pressure of a 3 bar without excessive effort on the part of the operator. The maximum force applied to the mid point of the handgrip of the pump lever to maintain this output should be not greater than 27 J.

Check valves

The check valves shall be liquid tight, and made of chemical resistant material. The valves shall function correctly when the sprayer is tested at twice the required working pressure 0.34 bar. The check valves shall be removed, subjected to a test in solvents (see Appendix E), replaced and retested.

Operating mechanism

The pump piston cup or diaphragm shall be operated by a plunger shaft and lever with suitable linkage. All parts shall be of chemical resistant material. The sprayer shall undergo the test described in Appendix D until a minimum of 300 hours operation, with water or spray as specified, has been completed. The size and selection of the sample shall be specified.

Piston pumps

The plunger washer shall be either one or two cup-washers or an O-ring, resistant to solvents. Where in the form of a cup-washer, it shall not be less than 2.4 mm thick and have a depth of face at least 9.5 mm in contact with the bore of the pump cylinder. A suitable spring or disc with chamfered edges may be provided to hold the washer skirt in position against the barred

face without distortion. Where an O-ring is used, its tolerances and those of its retainer in relation to the barrel bore shall comply with B.S.1806. The plunger washer should not expand and cause stiffening of the pump action during operation.

Diaphragm pumps

The diaphragm shall be resistant to solvents. The diaphragm shall be securely located and retained in place and withstand twice the normal working pressure plus 0.34 bar during operation for a minimum period of five minutes.

Pressure chamber

The sprayer shall be provided with a pressure chamber. Its volume shall be not less than ten times the output with one stroke of the pump and capable of withstanding twice the maximum working pressure plus 0.34 bar without leakage. The test shall be carried out before and after the durability test in Appendix D. (see also Appendix A.)

Handle

The lever shall be fitted with a hand grip or knob which is non-absorbent and shall not cause pain, discomfort or blistering when operated under field conditions for a normal working day. The strength of the handle and assembly, including the junction with the plunger rod shall not be less than that of the plunger rod.

Agitator

When specified, the sprayer shall be fitted with mechanical or hydraulic agitation to maintain a suspension of 0.5 percent a.i. D.D.T. (the D.D.T. formulation should be a 75 percent wettable power - W.H.O. Specification WHO/SIF/IR2) for a period of at least one hour without significant sedimentation on the bottom of the tank or excessive residue remaining in the tank after the liquid contents have been pumped out of the tank. A mechanical agitator fitted to the pump mechanism must be strongly secured, easily accessible and should have free guided movement to avoid interfering with the action of pumping.

Liquid entry and exist

The pump shall be designed so that the input opening is within 12.5 mm of the bottom of the tank at its lowest point. Similarly, the exit from the pressure chamber should be less than 12.5 mm from the bottom.

Strainers

The strainers shall be made of stainless steel, bronze, monel or suitable plastic material. The strainers should be of 50 mesh. One strainer shall be fitted to the filler hole and have a total

area of not less than 65 cm^2. Another strainer may be fitted to the pump inlet. The strainers shall have sufficient structural strength, or shall be mounted in such a way that they will not be subjected to accidental puncture or collapse. The strainer shall be securely positioned at least 50 mm below the level of the filler hole so that liquid cannot by-pass the strainer, which should be provided with an air vent. The strainer shall be easily removable and replaceable without special tools as it is preferable that they should be a push fit rather than screwed.

Hose

Hose may be of rubber, synthetic rubber, or plastic material. It shall undergo tests described in Appendix F. The hose should be tested where possible with the pesticides to be used in a particular control project. Hose of less than 12.5 mm diameter (external) shall be capable of bending through a half-circle of 75 mm diameter without kinking. Similarly, a larger diameter hose should not kink when fitted to boom.

Hose clips and connections

Hose clips shall be of the worm drive type with enclosed worm complying with B.S.3628. The units shall have no sharp edges and a minimum of extended projections liable to catch on clothing or other objects. The hose connections, complete with clip shall be subjected to a static hydraulic pressure test equal to twice the working pressure of the hose for a period of five minutes without leakage or structural failure (see Appendix F). The hose, after being fitted with clip and removed from the connection five times, shall not be damaged sufficiently to interfere with subsequent fittings.

Threaded terminal connections shall have independent nipple and cap. The cap shall have finished, hexagonal faces, opposing flattened surfaces, knurled faces or wing nuts of adequate strength and size to enable liquid tight joints to be made by thumb pressure at the highest designated operating pressure.

Cut-off valve

The cut-off valve or tap shall be capable of instantaneously and completely stopping the flow of liquid. The valve shall conform to B.S. 4115 Section 19. The cut-off valve may be replaced by a pressure diaphragm check-valve designed to operate at a stipulated pressure.

Boom

Each sprayer shall be fitted with a boom as specified.

Nozzle

General

The nozzle shall consist of a body, strainer, cap and interchangeable tip. The tip shall provide either a flat fan or cone spray pattern, and may consist of not more than two separate components. The angle of spray and rate of discharge for insecticide application shall be specified with a tolerance of ± 5 percent at a working pressure of 3 bar. The strainer shall be 50 mesh and arranged so that the flow shall be from the outer surface inward. Materials and means of attachment shall conform to B.S. 2968. Couplings shall be made to enable liquid tight joints to be made by thumb pressure at the highest designated operating pressure.

Pattern

The distribution of spray from any given type of nozzle shall be uniform. The uniformity of spray pattern shall be determined using a patternator as specified in B.S. 2968.

Erosion

When required by the purchaser, the nozzle tip discharge rate shall not increase by more than 6 percent of the specified discharge rate after 50 litres of a suspension of synthetic silica powder (20g/l) is discharged through the nozzle at a pressure of 3 bar. On fan nozzles, at least 65 percent of the central part of the pattern should continue to be uniform.

Gaskets

Gaskets shall be capable of being readily fitted in position. Where possible, gaskets should be partially or wholly recessed. Gaskets shall operate satisfactorily after a gasket immersion test (Appendix E).

Pressure gauge

A pressure gauge need not be fitted although provision for fitting a gauge to the lance may be specified by the purchaser.

Spare parts

A supply of spare parts is required for each sprayer delivered to allow routine maintenance. The value shall be at least 10 percent of the unit price and include all gaskets, plunger caps, spreaders and other parts liable to wear or be lost under field conditions. In addition other spare parts may be required, for example, pump rods, levers, pump assembly and pressure chamber to allow for complete overhaul of sprayers.

Tools

Wherever possible sprayers should be designed to eliminate as far as possible the need for tools. If a screwdriver is required, the slot should be designed to allow the use of a coin. When a special tool is essential, the purchaser should be notified and the tool made available with each sprayer.

Operation and Maintenance Manual

An adequately illustrated manual shall be provided. The manual shall include a complete list of regular and optional parts, instructions for dismantling and cleaning, instructions for routine inspection, adjustments and replacement of parts, and instructions for handling and using the sprayer. Names and addresses of agents should be included in the manual. The manual should be translated into an appropriate language, where necessary.

APPENDIX A

Leakage test

The sprayer complete with all fittings shall be filled to the maximum working capacity with paraffin and allowed to stand with the base at a height of 1 m above ground level with the boom, tap closed, at a height of 60 cm above ground level. After standing for six hours, there shall be no leakage at any joint.

APPENDIX B

Drop test

The sprayer is dropped in a free fall from a height of 60 cm onto a platform consisting of planed solid oak or similar wood, 5 cm thick by 90 cm square, and placed on a level cement, stone or hard-packed floor. The spray is tested in seven positions as follows: first when empty and then when filled to its working capacity with water.

(a) dropped on its base which is angled at 15^{o} to the vertical at the start of the fall, repeated for each side, back and front.

(b) dropped on its back - i.e. side oposite straps.

(c) dropped on each side.

The sprayer is dropped twice in each position when empty and twice when full. The sprayer shall be deemed to have failed if the tank leaks (Appendix A) or any part becomes permanently deformed.

APPENDIX C

Strap test

The tank shall be filled with water to its maximum working capacity and the sprayer hung from a solid support by the straps. The sprayer shall be lifted a distance of 30 cm and allowed to drop and hang by the straps 25 times. The assembly shall be deemed to have failed to meet the requirements of this test if any part of it breaks or becomes permanently deformed.

APPENDIX D

Fatigue Test

The use of the sprayer is simulated by fastening the sprayer by means of its straps to a rig so that the lever can be operated to pump successive loads of water or spray as directed by the purchaser. Depending on the type of sprayer, the test will be designed to discharge 140 litres of spray per hour at 1 bar or 100 litres per hour at 3 bar.

APPENDIX E

Gasket Test

All sealing devices shall be removed from the equipment and immersed in a test solution of 60 percent kerosene, 5 percent benzene, 20 percent toluene and 15 percent xylene for a period of 72 hours at a temperature of 24 + 3°C and then dried by hanging in air at 24+ 3°C for 24 hours. The gaskets, washers and 'O' rings shall then be replaced in their original position on the equipment and the sprayer tested with 140 litres of spray. Gaskets should be tested in petroleum napthalene.

APPENDIX F

Hose test

Part I: A length of hose, complete with hose connections and clips shall be fixed vertically to a support at the top hose connection and a weight of 82 kg attached to the hose connection at the bottom end. The hose shall not be permanently stretched by more than 5 percent of the original length at 18°C or 35°C.

Part II: A blank cap shall be fixed to the hose connection attached to one end of the hose. The other end of the hose shall be connected to a pressure line by means of the other hose connection with gauge. With the hose filled with spray liquid, twice the normal working pressure plus 0.34 bar shall be applied for a period of 30 minutes at 18°C and 35°C. There shall be no leakage from the hose or connections.

ANNEX 5

List of certain Institutions Providing Training in Pesticide Application Technology

AUSTRALIA

Queensland Agricultural College, Gatton

- one week short courses previously held in 1979, 1982, 1984 and Masters course in Crop Protection.

MALAYSIA

University Pertanian Malaysia, Serdang

- short courses in conjunction with the Malaysian Plant Protection Society, previously held in 1982, 1983 and 1985.

SWITZERLAND

CIBA-GEIGY, Basel, Switzerland

Application courses, held for two weeks at two or three separate times each year.

UNITED KINGDOM

- Cranfield Institute of Technology.

  Staff participates in overseas courses on request.

  International Centre for the Application of Pesticides (ICAP)

  - two week short course in aerial application (annual)

  - Masters course in Bioaeronautics (2 year)

- Reading University

  - Masters course in Crop Protection (1 year)

- University of London

  International Pesticide Application Research Centre.

  Silwood Centre for Pest Management

- Imperial College at Silwood Park

  Staff participates in overseas courses on request.

  - short courses on pest management (2 month)

    includes ground applicatin equipment.

  - special course on pesticide application on request.

  - Masters courses (1 year) in applied entomology, weed science, or plant pathology which includes 2 week section on pesticide application.

    Diploma of Imperial College - 1 year course by personal research.

Any institution not included in the above list should contact AGP, FAO, Rome.

ANNEX 6

AN EXAMPLE OF GUIDELINES ON PESTICIDE APPLICATION

Guidelines for Applying Crop Protection Chemicals

SAFETY

1.1 Whenever using crop protection chemicals always -

- ensure the operator has received appropriate training,
- follow the recommendations in the manufacturers' leaflets and product labels,
- comply with all current legislation,
- wear the required or recommended protective clothing.

1.2 If in doubt on any of these points consult the local office of the Health and Safety Executive, your local official agricultural adviser, chemical distributor, chemical manufacturer or the Agricultural Training Board.

FIELD CROP SPRAYING

2. **Preparing the sprayer for use**

On taking delivery of a new sprayer or removing a used sprayer from storage, lubricate the sprayer, inflate sprayer and/or tractor tyres correctly and carry out the following procedure:

2.1 **Pump**

Drain out and flush the pump with warm water containing a detergent and check that the driveshaft can be turned freely by hand.

2.2 **Sprayer tank**

Flush out the sprayer tank with clean water and ensure that the inside is clean. Give particular attention to the inside upper surface. Check that the tank lid vent is clear. If the sprayer has not been cleaned before storage, use the decontamination procedure (see section 14). Check that the tank is free from leaks. Flush out the sprayer system with filters and nozzle tips removed.

2.3 **Main filters**

Check that all the main filters and their seals are clean and undamaged, insert them correctly.

2.4 Nozzles

Check that all sets of nozzle parts, check valves and filters are clean and in good condition.

2.5 Sprayer check

Fit the smallest nozzle tips and nozzle filters supplied. Part fill the tank with clean water through the tank filter from a hose, not by the self-filling device (if fitted), to avoid damage to an empty pump. Check that the sight glass is operating correctly. Start the pump slowly, with the main spray "On-Off" valve turned to the "Off" position. Check that there is a good flowback to the tank free from air bubbles. See paragraphs 12.9 and 12.10 in "Identifying sprayer faults".

2.5.1 Progressively increase the pump speed, checking the function of all controls. Vary the pressure regulator settings and check that the pressure gauge reading changes and also that it reads zero when the pump is stopped.

2.5.2 Check that all the controls can be operated without any leaking in the system, and that all check valves function.

2.5.3 Check under pressure the condition of all hoses and couplings. Replace any which are abraded, softened, swollen, cracked or showing breakdown of the lining.

2.6 General condition

Check that,

- boom break-back works
- boom height adjusts freely
- boom sections are parallel to level ground
- wheels on trailed sprayer can be adjusted for correct spacing to tract correctly with the tractor wheels
- all safety guards are sound and in position.

3. Before spraying

The decision to spray should be made after considering,

- the degree of infestation
- official warnings given on
  - radio
  - television
  - telephone information services
  - in the press
- control measures available
- correct timing
- any previous experience
- the possible risk of the pest developing resistance
- the probable cost benefit of applying the chemical
- safety.

3.1 When discussing your chemical requirements with your agro-chemical distributor or manufacturer preference should be given to products in the latest edition of the 'Approved Products for Farmers and Growers'. Check the following:

3.1.1 **Operator Safety** - Can a less toxic alterntaive pesticide be used?

3.1.2 **Consumer Safety** - Can the chemical be applied in time to leave the necessary interval before harvest?

3.1.3 **Enviornmental Safety** - Can a chemical less likely to affect livestock, bees and wildlife be used?

3.1.4 **Safety to Crops on the Treated Area** - Is the variety of crop suitable, is the time of application correct and is the crop healthy and not under stress due to conditions prior to or at the time of spraying?

3.1.5 **Safety of Neighbouring Crops** - Is the chemical one that is least likely to damage crops in neighbouring fields, glasshouses and private gardens if it should drift?

3.2 Always follow the chemical manufacturer's instructions on safety precautions, the spray volume, the recommended dose and mixing and any other special requirements for best results. If spraying more than one chemical at the same time check that the mixture is recommended on the label(s) as being satisfactory and as not damaging to the crop or sprayer. The order of mixing can be important. See particularly paragraph 4.1.2 "Measure the calculated amount of chemical".

3.3 **Nozzles**

Select the nozzle size and type most suitable, following specific instructions given by the chemical manufacturers and the more general instructions given by the sprayer and nozzle manufacturers. In general it is preferable to use:

3.3.1 Low pressure cone or fan tips (operating from 0.75 - 1.5 bar) for residual and hormone type sprays where drift could be a problem.

3.3.2 Cone nozzles for applying fungicides, where coverage of the crop foliage is important.

3.3.3 Fan nozzles for good penetration of upright crops such as cereals, for example when applying insecticides and contact herbicides.

3.4 **Check calibration** - See paragraphs 8.1 - 8.3.1.6.

3.5 A few days before spraying

3.5.1 Ensure that there are adequate chemical supplies on the farm for the job in hand.

3.5.2 Ensure a readily accessible water supply and equipment for rapid filling. Where no clean water is readily available consider the use of an alternative formulation (e.g. dust, granules, ULV concentrates).

3.5.3 Check that you have the protective clothing to be used in good and clean condition.

3.5.4 Warn neighbouring farmers, and others living close to the site, of your spraying plans, so that if they wish they can take any precautions such as keeping livestock and pets under cover.

3.5.5 Read the label and if the chemical is harmful or dangerous to bees, warn local beekeepers and try to spray late in the day or on a dull cloudy day, if you can, when few bees are flying.

3.5.6 Ensure that swath matching equipment is prepared.

3.5.7 Decide how you are going to dispose of empty containers or unwanted chemicals following advice in the "FAO Guidelines for the Disposal of Wasted Pesticides and Pesticide Containers on The Farms".

3.6 On the day of spraying

3.6.1 Check,

- operator has read and understood the safety precautions
- appropriate protective clothing is available and is worn
- correct dose and dilution to be used
- the amount of chemical required for a full tank load
- pest, disease or weed is in a suitable condition for treatment
- crop stage of growth is correct
- ground conditions are satisfactory
- weather conditions and forecasts are satisfactory
- washing equipment is available.

4. Field techniques

4.1 Mixing

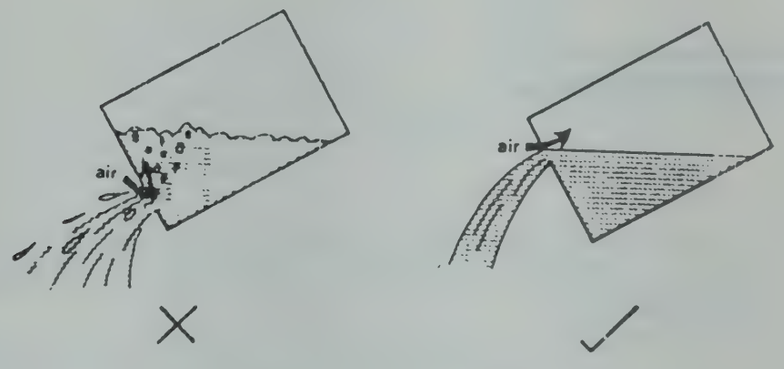
Follow the recommended procedure for mixing. This is important to ensure correct mixing, minimum foaming and avoidance of damage to the pump.

4.1.1 Part fill the tank with clean water through the tank filter to prime the pump before adding any chemical. Never add chemical concentrate to an empty sprayer tank. Take care not to make any

direct connections between a domestic water supply and the spray tank, to ensure that there can be no run-back of chemical into the water supply. Start the pump and check that the agitation is working correctly.

4.1.2 Measure the calcuated amount of chemical(s). Do not guess the amount. If using more than one material, or adding trace elements or extra wetting agents, do not mix the concentrates together, but add them separately to the water in the tank in the recommended order; and check that they are compatible. With chemicals which are known to foam, three quarters fill the tank with clean water before adding the chemical and use only gentle agitation until filling is completed.

4.1.3 Use the chemical filling attachment if fitted to your sprayer. WETTABLE POWDERS must be weighed unless in a suitable size pre-weighed pack. The manufacturer's mixing instructions must be followed. LIQUID FORMULATIONS must be measured out unless in containers of appropriate volume. Care should be taken when opening and pouring from cans or bottles that the outlet is in a position to avoid splashing - see illustration.



4.1.4 Wash out used containers and put the washings into the tank.

4.1.5 Fill the tank to the required level with water, while agitating the contents. Continue agitating until spraying is finished unless otherwise stated in the instructions. If there is any delay between mixing and spraying ensure that the tank contents are agitated regularly and especially just prior to use.

4.1.6 Wash any spilt chemicals off the sprayers and containers. Any container or tank in which any chemical is stored should be closed or covered over between use. Ensure that children and livestock are unable to reach them.

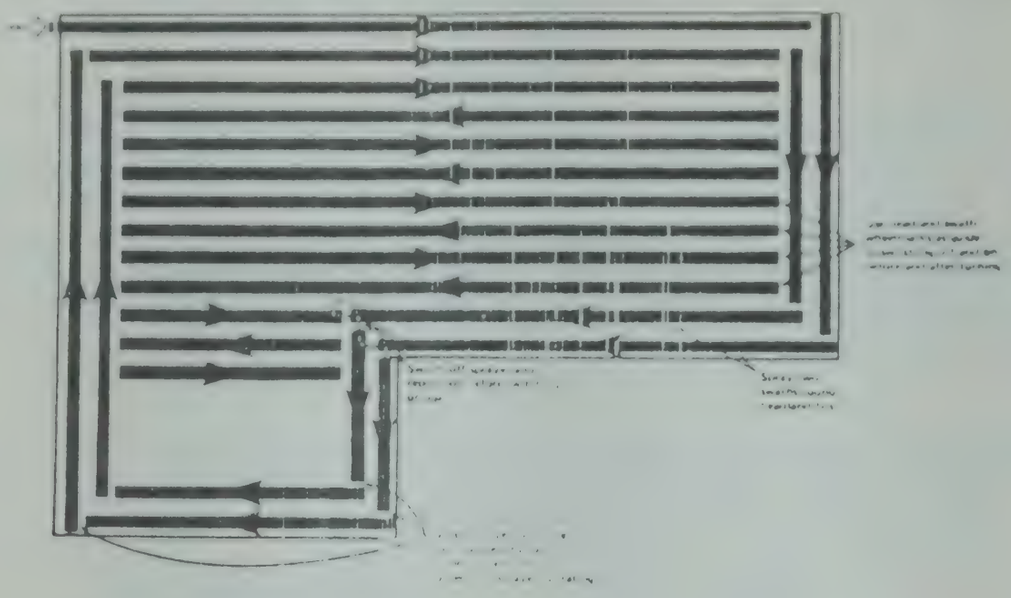
4.1.7 Wash down any impermeable protective clothing such as rubber boots, gloves, apron or face shields.

4.1.8 Before entering the tractor cab remove any protective clothing not required by law (other than overalls and rubber boots) and place it in the tractor locker, not in the tractor cab.

4.2 **Spraying**

4.2.1 Check the nozzle height above the target in the field. See section 10.

4.2.2 The correct method of spraying in a field not in a row crop is shown in the diagram below.



4.2.3 To avoid overlapping spray swaths or missing stripes, use one of the proven methods of swath marking other than pacing, which is too inaccurate.

4.2.4 When spraying row crops or bed systems it is essential to use a swath width which is a multiple of the row width or the bed width.

4.2.5 Maintain the speed and pressure as determined during calibration (see paragraphs 8.3.4e and 8.3.15) unless using a sprayer fitted with an automatic regulating system.

4.2.6 Do not spray whilst turning. See paragraph 4.2.2.

4.2.7 Check the tank contents gauge frequently and as soon as the tank is nearly empty disengage the pump drive to avoid damage to the pump. If the spray runs short during a run across the field, after stopping the pump do one of two things to indicate the limit of spraying.

a. Where appropriate (e.g. in cereal crops) turn out of the wheelings at right angles into the sprayed crop and into the previous wheelings.

b. In beds, mark the ground and drive forward out of the crop.

4.2.8 Keep a regular check on nozzle spray patterns throughout spraying. If any fault is seen to be developing attend to this at the headland. See section 12.

a. Always carry spare nozzles of the correct size.

b. Whenever changing nozzles wear the protective clothing as shown on the product label.

c. Never put a nozzle to your mouth. Never prod with wire or pin to clean a blocked nozzle. Faulty nozzle parts should be placed in a watertight container and attended to at the farm.

d. If there is any delay agitate the tank contents thoroughly before recommencing spraying.

4.2.9 During spraying the operator should constantly check and if necessary rectify -

- boom height
- boom bounce and whip
- spray pressure
- forward speed/engine speed
- nozzle performance
- drift
- swath matching
- level of spray liquid in the tank.

See sections 12 and 13 for advice on identifying and correcting spraying faults and errors in spraying.

4.3 **After spraying**

4.3.1 In accordance with the "FAO Guidelines for the Disposal of Wasted Pesticides and Pesticide Containers on the Farms".

- return unused chemicals to safe storage. See also "FAO Guidelines on Packaging and Storage of Pesticides"

- dispose of empty containers

- dispose of any spray liquid in the tank

- dispose of the tank washings.

Sprayers should be cleaned immediately after the job is finished and before changing to a different chemical. Leaving the sprayer overnight without washing may cause damage.

4.3.2 Allow the sprayer to drain completely, not forgetting the pump, especially if frost is likely.

4.3.3 A full decontamination procedure (see section 14) must be used when changing from one chemical to another.

5. Storing the sprayer

5.1 Cleaning and checking the sprayer

5.1.1 Decontaminate the sprayer. See section 14.

5.1.2 Use an airline to blow out nozzles and filters.

5.1.3 Check the sprayer for wear or damage and order replacement parts.

5.1.4 Carry out the manufacturer's lubrication instructions and any other special instructions.

5.2 Storage

5.2.1 Place the sprayer out of direct sunlight in a clean, dry shed. Store nozzles and filters in a plastic container in the filter basket. Check that the tank lid is slightly ajar to prevent condensation, which may cause damage to sprayer components.

5.2.2 Observe the frost precautions in the manufacturer's instruction book.

5.3 Protective clothing

5.3.1 Wash impermeable protective clothing, including the inside of rubber gloves, at the end of each day's work and overalls and hoods at least once in every six days of use or more frequently if they become badly contaminated. Respirators and dust masks should be carefully cleaned and dried after each day's work, but water must not be allowed to run into the respirator canister or connecting tube.

5.3.2 Check the condition of protective clothing after use; replace any which is damaged. Rubber gloves in particular should be discarded whenever even very minor damage is evident.

5.3.3 The filter of any respirator/dust mask which has been used for the maximum period recommended by the manufacturer, or which, after careful checking of the facial fit of the mask, permits the operator to smell the chemical, should be replaced.

5.3.4 Store the protective clothing in its own ventilated locker.

BAND SPRAYING

6.1 Most of the points concerning field crop spraying apply equally to band spraying.

6.2 For calculating the amount of chemical required and calibrating and adjusting the sprayer, see section 9 and 11.

6.3 When drilling and spraying in one operation the tank should be topped up regularly at the headland from a tank or drum of premixed chemical(s).

6.3.1 Always agitate the mixture thoroughly in the drum before transferring to the sprayer.

6.3.2 Always agitate the sprayer tank contents before starting to spray.

USEFUL PUBLICATIONS

See FAO Conductof Conduct on the Distribution and Use of Pesticides, FAO, Rome, 1986.

CALIBRATING FIELD CROP SPRAYERS

8.1 Always consult the sprayer manufacturer's handbook.

8.2 Always calibrate -

- at the beginning of each season
- at every 100 hectares (250 acres)
- after changes of tractor or sprayer wheel tyres, nozzle tips or operating pressure
- follow a calibration procedure.

IDENTIFYING SPRAYER FAULTS (See paragraph 4.2.8)

	FAULT	PROBABLE CAUSE	ACTION REQUIRED
12.1	No spray from nozzles when spray is turned on.	1. Tank empty	Fill tank
		2. Air in the system	Prime pump and run long enough to expel air.
		3. Pump filters or nozzle filters blocked	Dismantle filters, clean and re-assemble.
		4. Tank outlet blocked.	Clear blockage

		5. Nozzle assembled incorrectly	Take nozzles apart and re-assemble as shown in manufacturers' instruction book.
		6. Pump(s) faulty	Fit new or re-conditioned pump(s).
12.2	When spray is turned on it stops after a short time	1. Filters blocking up	Dismantle filters, clean and re-assemble
		2a. Dirty water supply	Use only clean water where possible
		3. Sprayer tank is airtight	Clean out the vent before tank collapses.
12.3	Less spray from some nozzles than others	1. Nozzles starting to block	Replace nozzles
		2. Mixture of nozzle sizes fitted	Check output code on each tip and fit correct size
		3. Nozzles worn	Check ouput individually, fit new nozzles. Clean blocked nozzles on the farm
	Less spray from nozzles on one boom compared with another	Isolation tap not fully opened or blocked	Check - rectify

12.4	Nozzles at end of spray bar have a low output and fault persits after exchanging nozzles	Inadequate pump output for size and number of nozzles used	Fit new or reconditioned pump or smaller nozzles
12.5	Poor tank agitation	1. Pump faulty or inadequate	Fit smaller nozzles or reconditioned pump
		2. Return pipe partially blocked	Clean out
12.6	Pressure gradually increasing, spray decreasing	1. Nozzle filters blocking	Dismantle nozzles, clean filters, refit and check the pressure is normal1/
		2. Pressure gauge strained	Turn spray off and check that needle returns to zero. If it does not, fit a new gauge.
12.7	Pressure falling off	1. Pump filter blocking	Dismantle, clean and refit filter
		2. Nozzles wearing out	Fit new nozzle parts of same size
		3. Pump worn	Fit new or reconditioned pump
12.8	Spray angle unusually narrow	1. Pressure too low See also section 12.4	Increase pressure. See also section 12.4

		2. Pressure low and nozzle sputtering	Tank is nearly empty, see paragraph 4.2.7 or air is leaking into the pump or pipe-work. Locate and repair leak.
		3. Partly blocked nozzle	Fit clean nozzle
12.9	Coarse foam in sprayer tank	1. Return pipe above level of liquid in tank	Extend return pipe down to bottom of tank
		2. Over vigorous agitation during filling	Fill sprayer with care
		3. Air sucked back into tank by anti-drip device	Turn off boom taps when filling and agitating the spray liquid
12.10	Fine foam in sprayer tank	Air is leaking into suction side of pump or into pump itself	Locate and stop the air leak
12.11	Spray pattern on dry ground is streaky	1. Nozzles partly blocked by dirt	Replace nozzles
		2. Nozzles worn	Replace with new nozzle parts of correct size and test again
		3. Fan type nozzle(s) mis-aligned	Re-align, parallel to spray bar
12.12	Nozzles drip when boom switched off	Anti-drip device faulty or not fitted	Repair or install anti-drip device. Re-calibrate

13.1	Stripes longitudinally at spacing of nozzles	Nozzles too low	Adjust boom height
13.2	Stripes longitudinally	1. Pressure too low	Adjust pressure or remove blockage in pipelines (probably the filter)
		2. Nozzles worn or damaged	Replace nozzles
		3. Foam in spray liquid	Find causes of foaming and correct. See section 12.3
13.3	Short, intermittent stripes at position towards spray boom ends	Spray boom bounce vertical	If spray boom swings up and down by say 30 cm, the whole boom should be raised half this height, i.e. 15 cm.
13.4	Stripes at right angles to spraying direction at position towards spray boom ends	Spray boom swings horizontally	Loose linkages, spray boom hinges, spray boom height etc should be attended to
13.5	Uneven patchy results	Gusty wind or combination of some of above faults	Avoid spraying in gusty winds or as above where appropriate

13.6	Crop damaged on first swath, poor weed control on subsequent swaths	Pesticide not properly mixed with water in spray tank	Mix pesticide thoroughly and check agitation when next spraying. See paragraph 4.1.1

DECONTAMINATING THE SPRAYER

14.1 If an **emulsifiable concentrate** was last used, fill the tank with clean water and add about 50 ml of a household liquid detergent per 100 litres of water. Agitate thoroughly and spray out half the liquid through the nozzles, then remove the nozzle tips and filters, placing them in a bucket of clean water. Remove the spray bar end caps (if possible) and pump out the rest of the cleaning mixture.

14.1.1 Refill with clean water only. If possible allow to stand overnight unless frost is expected.

14.1.2 Drain completely.

14.2 If any other type of sprays have been used, for example

- solutions in water
- wettable powders
- suspension concentrates,

the same procedure as in paragarphs 14.1 to 14.1.2 should be used but omitting the detergent.

ANNEX 7

Spray Classification

The following categories of spray quality were agreed by the Group:

	Droplet size 1/ range
Fine Aerosol	0 - 25 /um
Coarse Aerosol	25 - 50 /um
Mist	50 - 100 /um
Fine Spray	100 - 200 /um
Medium Spray	200 - 300 /um
Coarse Spray	> 300 /um

1/ As Volume Medium Diameter (VMD), but the full spray spectrum should be considered. In some countries reference nozzles are designated for specific categories.

ANNEX 8

A Code for Hydraulic Nozzles

This code allows particular nozzles to be specified without using manufacturer's individual codes or terminology. The standard rated pressure for hydraulic nozzles is 3 but except where nozzles are designed for low pressure (designated *below) operation in which case they are noted at 1 bar.

The code consists of few components:

a) Type - denoted by a letter

b) Spray angle at rated pressure

c) Nozzle output in litres per minute at rated pressure

d) Rated Pressure measured in bar

The letters to describe type are:

F = Triangular flat fan

FE = Rectangular flat fan used for even spray "band" treatment

FLP = Low pressure flat fan*

HC = Hollow cone

D = Deflector*

An example is:

F110/1.6/3 = fan nozzle with 110^{o} angle emitting 1.6 litres per minute at 3 bar.

NOTE: 1 bar = 100 kPa.

ANNEX 9

Classification of Volume Rates

The Group agreed that while it is preferable to state the recommended volume, a classification of different volume ranges is useful.

The terminology adopted to describe certain volumes is similar to that published by the European Plant Protection Organization (EPPO), as follows:

		Volume in litres per hectare	
		Field crops	Tree crops
ULV	- ultra low volume	<5	<50
VLU	- very low volume	5-50	50-200
LV	- low volume	50-200	200-500
MV	- medium volume	200-500	500-1000
HV	- high volume	>500	>1000

NOTE: WHO defines ULV as the minimum volume to achieve economic control.

M/S2155/E/12.86/1/1200